AnSim

Analysis and Simulation, Inc.

172 Holtz Road, Buffalo, New York 14225 (716) 632-4932 Fax: (716) 632-4935

DATA ANALYSIS OF X-RAY IMAGE SYSTEM (DAXIS)

Phase I

Final Report

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Prepared by:

James A. Leone, Principal Investigator
Jingquan Li
Paul Patti
Xinran Wang

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James A. Leone, Principal Investigator;
Jingquan Li, Paul Patti, Xinran Wang

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172 Holtz Road
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13. ABSTRACT (*Maximum 200 words*)

Report Developed Under SBIR Contract. The AnSim project "DAXIS - Data Analysis of X-Ray Image System, developed a prototype digital imaging processing sequence for object identification and classification using the filtering/predictive capabilities of wavelets, fractals and artificial neural networks (ANN). Each of these analytical techniques has its own characteristics which, when used in combination, were anticipated to synergistically assist in meeting the overall objective. A number of wavelet families were investigated as image filters for object location and identification. When combined with conventional imaging processing techniques and a fractal dimension calculation, a number of quantitative object characteristics were determined. These characteristics were placed in a feature vector and submitted to neural network analysis for purposes of object classification. The prototype was developed and a set of x-rays were used to train a neural network which was then tested in classifying anomalies found in another government-furnished set of x-rays.

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The technical program reported herein was conducted from November 4, 1996 to May 3, 1997 by Analysis and Simulation, Inc. (AnSim), Buffalo, New York for the Department of the Army, U.S. Army ARDEC, Picatinny Arsenal, New Jersey.

The work was performed by AnSim employees Piara Arzumand, Peter Huang, Jingquan Li, and Xinran Wang under the supervision of James A. Leone, Ph.D., Prinicipal Investigator. Mr. Paul Patti, President of Analysis and Simulation, Inc., also provided technical support and management review. Ms. Patricia Pfohl provided administrative as well as report/presentation preparation support.

Extensive expertise was provided by M. Raghuveer Rao, Ph.D. and Zoran Ninkov, Ph.D. from the Rochester Institute of Technology, and Raj Acharya, Ph.D., from the State University of New York at Buffalo. Dr. Rao provided guidance on wavelet algorithms and technology, while Dr. Ninkov facilitated the development of x-ray images necessary to the project. Dr. Acharya provided expertise in fractal algorithms.

Performance of the program depended on close collaboration and cooperation of ARDEC--particularly the guidance and critique of Dr. Paul Willson, COTR, who also provided radiographic images necessary to the successful performance of this project.

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I. EXECUTIVE SUMMARY

Analysis and Simulation, Inc. (AnSim) was awarded a contract (No. DAAE30-97-C-0003) by the Department of the Army, U.S. Army ARDEC, Picatinny Arsenal, NJ, in response to Topic A96-002 Army 96.2 Phase I SBIR solicitation, entitled "Analysis of X-Ray Images using Wavelet and Fractal Methods" (Appendix A). The solicitation objective was to develop "an x-ray data analysis system in which fractal and wavelet analysis methods are integrated with more traditional methods of analysis in analyzing x-ray multispectral images for identification of objects, object positions, and composition." The Army's needs were to have "a limited but fairly numerous set of parameters that could be quickly calculated from x-ray radiographic images...adequate to identify and differentiate with a very high level of probability a host of materials both man-made and natural as seen in the radiographs."

The AnSim project, "DAXIS - Data Analysis of X-Ray Image System," covering the period from November 4, 1996 through May 3, 1997, sought to develop a prototype ("best first guess") digital imaging processing sequence for object identification and classification using the filtering and predictive capabilities of wavelets, fractals and artificial neural networks (ANN). Each of these analytical techniques has its own characteristics which, when used in combination, were anticipated to synergistically assist in meeting the overall objective. The specific Phase I objectives were:

1. Select the data set; ensure the knowledge base meets the needs of the Army.
2. Perform the DAXIS system design and develop the functional specifications of the modules required to adequately address the practical issues involved in implementing the Phase I prototype.
3. Develop the Phase I prototype and work with consultants to ensure the descriptive features of the radiographs are sufficiently characterized to enable object identification from those radiographs for which images are available.
4. Demonstrate Phase I prototype in order to assess feasibility and ultimate system potential by analyzing "unknown" radiographs supplied by the Army.

The initial image set supplied by the Army contained: (1) images of travel luggage, and (2) semicircular, molded chemical rocket motor propellant castings. AnSim prepared a second set of radiographs at 40μ pixel resolution of selected items of fruit. Addressing certain regions of interest (ROI) within the two image sets, specific object characteristics were then developed. A third image set acquired by AnSim included 328 digital mammograms assembled by the Mammographic Image Analysis Society (MIAS) in the UK. The mammograms were categorized as normal, containing benign masses, or containing malignant tumors. Each image had been evaluated by radiologists using thirteen quantifiable characteristics. These characteristics were used to "tune" NETS, the NASA developed ANN which AnSim planned to use as the prototype's "object classifier" system.

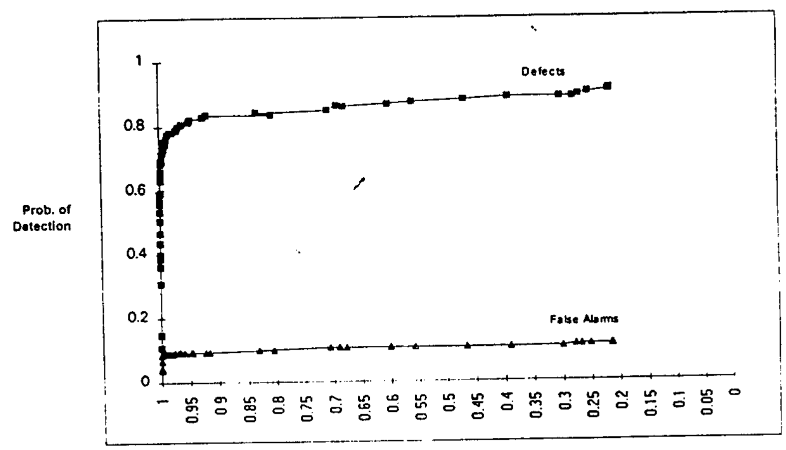
The primary focus of the Phase I prototype focused on analyzing propellant castings for production defects from a subsequent set of 1479 images supplied by the Army. Selected conventional image pre-processing techniques, such as median filtering and background subtraction, were implemented prior to using wavelet techniques for noise filtering and subsequent edge detection. We experimented with a number of common wavelets: Mallat Battle-Lemarie, Burt-Adelson, Coifflet (2, 4 & 6), Daubechies (2, 6, 8, 10, 12 & 20), Haar, PseudoCoifflet, and Spline (2-2, 2-4, 3-3 & 3-7).

The study attemped to balance issues like processing times, frequency response, filtering anomalies, and defect size. Ultimately, optimum results were obtained with the Coifflet-2 wavelet, image decomposition to five levels, discarding all three high frequency coefficient sets from the level one decomposition and the low frequency (residual) coefficient set from level five and then reconstructing the image.

Gradient processing combined with hard thresholding gave a set of "edge segments" which could be associated with selected image abnormalities. Using a seed growing algorithm, the image anomalies were collected into object sets for subsequent processing. A feature vector consisting of nine derivable characteristics was prepared for the ANN. The components of the feature vector include: (1, 2) the x, y coordinates (pixel) of the center of the anomaly, (3) anomaly area in pixels, (4) ratio of horizontal to vertical anomaly dimension, (5) ratio of anomaly area to anomaly bounding box area, (6) ratio of anomaly mean pixel gray level value to the mean gray level value of the region immediately surrounding the anomaly, (7) variance of gray level values within the anomaly, (8) isoparametric inequality of anomaly (measure of "roundness"), and (9) the fractal dimension of the anomaly.

The 1479 propellant casting images were partitioned into five sets of 250 images each and one of 229. Using a modified Delphi approach, each image was analyzed by select An-Sim staff to determine the defect(s) location, if any, in each image. Anomalies as small as 2x2 pixels and 2x1 pixels were "assigned" defect status if definitive (sufficient contrast). The upper limit of defect size was restricted to a size smaller than 30x30 as that size equaled a series of "calibration" disks inserted into select castings for QC purposes. By re-initializing the neural network, combinations of one or more image sets could be used to train the network and other sets submitted for analysis. Further variability was possible by removing one or more numerical quantities from the feature vector.

Figure 1.
PROBABILITY OF DETECTION vs. DETECTION THRESHOLD VALUE
[Training Sets 1, 2, & 6, Tests 3, 4, & 5]



As a result of the above experimentation, the Phase I prototype demonstrated very good capabilities for detecting defects within the castings. Figure 1 summarizes the results by plotting probability of detection against the detection threshold value for both defects detected and false alarms. Probabilities of defect detection ranged in the 80% to 90% while "false alarms" remained under 10%. The majority of missed detection of defects and false alarms occurred at the low end of defect sizes. A contributing factor to these results, based on a re-analysis of the affected x-rays, was inconsistency in the identification of defects by the "experts." A more rigorous application of the Delphi approach (more experts and increased consensus generation) would result in improved results. The second factor was the lost effectiveness of some components (4, 5, 7, 8 described above) of the feature vector. Refinement of the remaining components (i.e. fractal dimension of the anomaly), and/or additional component(s) would improve the results. The use of fractal dimension proved helpful in reducing the number of false alarms detected. If the training set includes images with calibration disks, the detection of very large defects (or calibration disks for that matter) is significantly improved.

II. SYSTEM DEVELOPMENT AND IMPLEMENTATION

II.1. INTRODUCTION

The Phase I DAXIS goal was to develop a prototype ("best first guess") digital imaging processing sequence for object identification and classification using the filtering and predictive capabilities of wavelets, fractals and artificial neural networks (ANN) in response to the DoD Solicitation 96.2, Topic A96-002 and included as Appendix A. Each of these analytical techniques has its own characteristics which, when used in combination, were anticipated to synergistically assist in meeting the overall objective. The specific Phase I objectives (see Executive Summary) were to (1) select image data set(s), (2) develop functional specifications, (3) code a prototype, and (4) assess the prototype against a sufficiently large enough data set to demonstrate feasibility. In order to design a system to meet the Army's goals, AnSim had to be sure the image data set(s) and the characteristics of the region of interest (ROI) were sufficiently complete that (1) a neural network analysis would ensure the DAXIS prototype met the Army's goals, and (2) the sequence of image processing procedures were capable of producing quantifiable values representative of the characteristics inputted to the neural network.

II.2 SELECTION AND CHARACTERIZATION OF THE DATA SET

The initial data set supplied by the COTR contained two categories of digital images:(1) passenger luggage and (2) semicircular, molded chemical rocket motor propellant castings taken as part of a quality control program for detecting defects within the propellant. AnSim prepared a set of high resolution radiographs of the following items in two orientations: apple, orange, banana, peach, pear, kiwi, and pepper. The images were captured on film and scanned by densitometer at a pixel resolution of 40μ and are shown in Appendix B. The items, exclusive of background, spanned approximately 200 pixels on a side. These images were used in our early tests of various wavelet filters and fractal dimension calculations. The third set, digital mammograms, was assembled by the Mammographic Image Analysis Society (MIAS) in the UK, and contains 328 images categorized as normal, benign mass or malignant tumor; three representative images are shown in Appendix C. Each image had been evaluated by radiologists using thirteen quantifiable characteristics. These characteristics were used to "tune" NETS, the NASA developed ANN which AnSim planned to use as the prototype's "object classifier" system.

Using the images in these data sets as representative objects of interest, image characteristics were developed and are listed as either general or specific features as follows:

<u>General Features</u>

1. Number of objects in the whole image, i.e., points of interest
2. Presence of similar objects elsewhere
3. Fatty or dense background
4. Shape: geometric (rectangular, oval, polygonal, etc.) to irregular
5. Linear to spherical, geometrical to diffuse
6. Length/width ratio
7. Measurement of curvature along the boundary

8. Complete to inseparable from surrounding
9. Well-defined to indistinct (margin)
10. Smooth to coarse (measure contour by fractal dimension)
11. Area of mountainous surface (the absolute value of the difference between the average and the fractal dimension of a region near the point of interest)
12. Radiation at center
13. Variation of degree of intensity in gray scale resolution (degree of skin thickening)
14. Angle of placement of the object
15. Distributed solid particles in inner part to see the seeds
16. Asymmetry
17. Determination of centroid
18. Spiculated masses (?stem)
19. Architectural distortion
    - subtlety of distortion
    - distortion definable on two views
    - presence of similar patterns elsewhere
    - degree of skin thickening
    - association with primary suspicious abnormality
20. Present in clusters
21. Shape of cluster, geometric (rectangular, oval, polygonal, etc.) to irregular
22. Location of the object in x y coordinates and approximate mean diameter

<u>Special Features</u>

1. Pattern of density
    - uniformity of density of mass (solid or not)
    - presence of well-defined lucencies (shines or not)
    - opacity relative to size
2. Multiplicity of density
3. Uniformity of density
4. Asymmetry relative to opposite side (banana)
5. Correlation of positions from 2 views
6. Margin spiculation (orange)
    - number of spiculations
    - length of spiculations
    - difference between spiculations and local linear features

These characteristics are a composit of three overlapping sets developed after a careful review of the three sets of images. As the prototype evolved, characteristics from the list above were matched against image ROIs. Reoccurring features such as shape, irregularity, density, texture, etc. led to the development of a set of nine characteristics targeted for the propellant casting defects and are discussed in Section II.3.3.

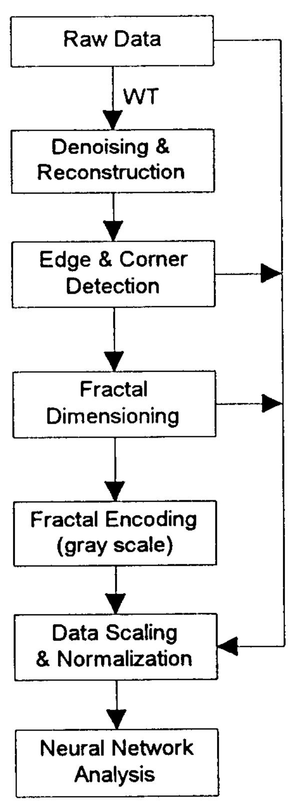
II.3 SYSTEM DESIGN

System design began with a review of our image processing sequence as shown in Figure 1 of our Phase I SBIR proposal which is shown here as Figure 2. Note that the outputs from the wavelet and fractal analysis were to be used as inputs to the ANN, including feature values obtained from the radiologists' interpretations. A statistical analysis was anticipated here to obtain the most significant variables (inputs) for use by the ANN model.

Under wavelet and fractal analysis, the main parameters proposed for the identification and differentiation of image objects were to be: curvatures, contours (edges), and fractal dimensions (of the edges and/or image itself). The required steps were to be: (a) image noise suppression, (b) image decomposition using wavelets to determine contour information, and (c) candidate objects encircled by the contours.

Other than the above mentioned wavelet and fractal representations, we planned to use for the ANN algorithm features described by Geiger et al related to masses, i.e., shape, size, margin, spiculation, and pattern. The classifications were: (1) shape of density--linear to spherical, geometrical to diffuse, (2) size of density--approximate mean diameter, (3) margin of density--complete to inseparable from surroundings, well-defined to indistinct, presence of halo sign, (4) margin spiculation--number of spiculations, length of spiculation, difference between spicules and local linear features, and (5) pattern of density--uniformity of density of mass, presence of well defined lucencies, opacity relative to size.

As is typical with Phase I SBIR rapid prototyping efforts, several activities were begun in parallel. One of those efforts was to acquire public domain versions of a number of wavelets and select representative ones suitable for the tasks at hand. It became apparent that a wavelet family useful for analyzing the baggage was not suited to analyzing the propellant castings. Thus, it is appropriate at this point to discuss AnSim's wavelet and fractal algorithm development efforts in context with the interim presentation on February 20, 1997 before describing the finalized image processing sequence demonstrated at the May 13, 1997 presentation.



WT = Wavelet Transform

Figure 2. Image Data Processing

II.3.1 Techniques Evaluation

By the time software and materials had been prepared for the interim presentation, we had developed separate processing sequences to handle the baggage and propellant casting images. Briefly, the baggage sequence was:

1. Histogram equalization
2. Daubechies-8 wavelet transform to 3 levels and filtering out all diagonal coefficients and residual (see Section II.3.1 for explanation)
3. Histogram equalization
4. Gradient
5. Adaptive threshold
6. Clean (removal of isolated "noise" pixels from binary image)

The propellant casting sequence was:

1. Haar wavelet transform to 3 levels and filtering out all diagonal coefficients and residual (see Section II.3.1.1 for explanation)
2. Histogram equalization
3. Gradient
4. Thresholding
5. Clean (removal of isolated "noise" pixels from binary image)

Discussion with the COTR after the February 20, 1997 presentation resulted in a decision to focus attention on developing a processing system that would show the feasibility of an automated detection system to identify defects in the propellant castings. As a result, several experiments with wavelet and fractal filtering sequences were carried out. Thus, before discussing the image processing sequence, the analysis of wavelet and fractal investigations will be reviewed.

II.3.1.1 Wavelet Applications

Multiresolution analysis of 2-D image structures by wavelet transform provides a scale-based decomposition and is a very good procedure for separating image components by frequency. Thus, removal of selective components in the wavelet domain is a useful filtering technique for de-noising. Significant regions of the propellant casting images are uniform; i.e. a defect-free casting is a chemical composite of uniform density. Thus, the predominant noise is high frequency and due to statistical fluctuations in X-ray photon detection and the grain size in the screen-film combination. There is a gradual change (low frequency) of the gray level in all of the grain images which is most likely due to the shape of the casting and its container (see Section II.3.1.1.1).

There have been several investigations into additive noise suppression using wavelet transforms such as that of Donoho and Johnstone which is based on thresholding the discrete wavelet transform of an image and then reconstructing it [don94] [don95]. This method relies on the fact that noise commonly manifests itself as high frequency components in the image and the wavelet transform provides a scale-based decomposition. Thus most of the noise tends to be represented by wavelet coefficients at the finer scales. Also, the coefficients at the finer scales carry most of the edge information. The method of Johnstone and Donoho,

therefore, thresholds the wavelet coefficients in the finer scale parts to zero out values below a threshold. We used several wavelets with different thresholds early in our investigations using images from both the baggage and propellant castings sets. A significant amount of edge information became available; much of it directed toward the complex baggage images but not necessary for most of the propellant casting (grain) images.

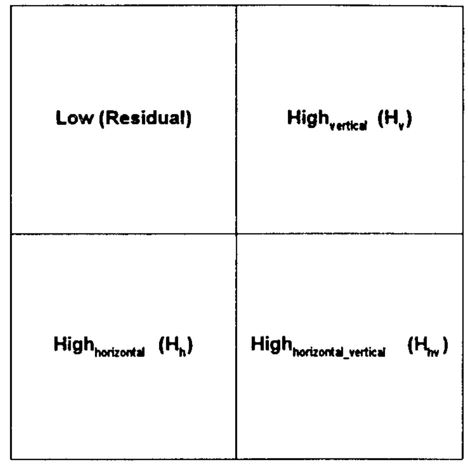


Figure 3. One Level Wavelet Decomposition

Even with images as bland (lacking a rich mixture of frequency components) as the propellant castings, the effects of multiresolution can be elegantly demonstrated. First, a quick review of some terminology and the method by which wavelet decomposition information is graphically represented. Figure 3 represents a one-level decomposition which shows the three high frequency wavelet coefficients (horizontal, vertical, and combination) and the low frequency coefficients--sometimes referred to as the residual or coarse components. Although these coefficients span a wide dynamic range (±3000), they can be rescaled to 0-255 for image display of the wavelet domain. Figure 4 shows a three level decomposition. Note that the three high-frequency-coefficient sets from a one-level decomposition, $H1_h$, $H1_v$, and $H1_{hv}$, are left intact.

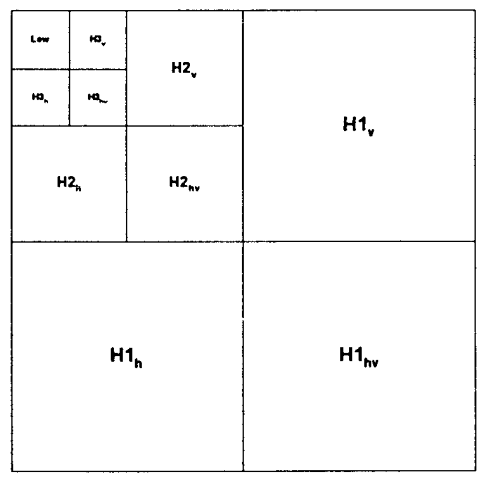


Figure 4. Three Level Wavelet Decomposition

The process of filtering involves selecting one or more blocks of coefficients for selective processing or removal followed by inverse wavelet transformation, i.e., image reconstruction. One can choose only high frequency components such as $H1_h$, $H1_v$, and $H1_{hv}$; intermediate components such as $H2_h$, $H2_v$, and $H2_{hv}$; very low frequencies such as the coarse block (residual or low frequency block); or, for that matter, the diagonal components $H1_{hv}$, $H2_{hv}$, and $H3_{hv}$.

For reasons that will become apparent shortly, we decomposed the propellant castings to five levels and discarded the three high frequency blocks from level one ($H1_h$, $H1_v$, and $H1_{hv}$) and residual from level five as shown in Figure 5.

II.3.1.1.1 Multiresolution Analysis

Using the side view of the the propellant castings, the impact of multiresolution analysis can be clearly shown using a Coifflet-2 filter series. Figure 6a shows a casting with a large defect in the upper right side. This was file "grain1405" as supplied by the COTR. Figure 7a shows the line profile obtained through that defect. A line profile is simply a plot of pixel value Vv. pixel position for one of the rows of the image's pixel matrix. Figure 6b is the resultant image after one level of decomposition followed by reconstruction of $H1_v$, $H1_h$, and $H1_{hv}$ only. In

other words, reconstruction without the coarse block. The only feature apparent in Figure 6b is the background noise. Figure 6c is the result after two levels of decomposition followed by reconstruction of $H2_v$, $H2_h$, and $H2_{hv}$ only. Figure 6d is the result after three levels of decomposition followed by reconstruction of $H3_v$, $H3_h$, and $H3_{hv}$ only. Finally, Figure 6e is the result after five levels of decomposition followed by reconstruction of the coarse block only. Figures 7b through 7e are the corresponding line profiles. As one can see, the large defect is visible in the reconstructed images only at certain scales (frequency ranges). Based on this analysis it is reasonable to assume, in the absence of all other issues, a 5-level decomposition followed by a reconstruction using only the levels 3 and 4 high frequency coefficients would be a good filtering procedure.

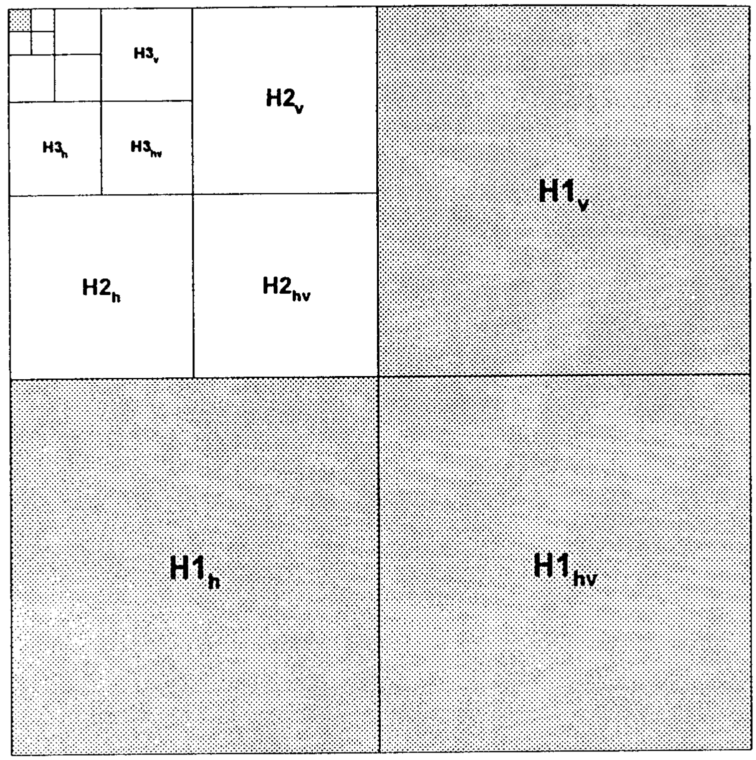


Figure 5. Five-Level Decomposition and Filter Sets

With the propellant casting images, the desired defect signal is buried inside both high and low frequency noise. Most of the defects are small in size (around 15 pixels in width or height); the largest defect is 60 pixels in width (or height) compared to the image size of 512 x 496. The defects usually have a distinctive gray value to its surrounding background area. In this case, defect edge information is not as important as de-noising as much as possible without suppressing the defects which lie in the somewhat higher frequency band of the image. In order to get rid of the low frequency noise in the grain image (gradual change in gray level), we intended to discard the coarse component of the wavelet transform. We tried several choices of transform levels on images with various sizes of defects. The result was that small defects of size 10-15 pixels are retained after discarding the coarse component of 3 levels of wavelet transform. However, larger defects contained more low frequency components and needed more levels of decomposition. We went to 5 levels for the largest defects. Because the defects were relatively small and they were quite close to the noise in high frequency band, we simply discarded the high frequency portion (wavelet coefficients at the finer scale) of the first level of wavelet transform. Very late in Phase I, soft thresholding in the wavelet domain was tried. Results were inconclusive and will be an important avenue of investigation in Phase II.

For the following sequences, the casting image used was filename "grain0002" and contained three small defects on the left side. Figure 8a shows the original image; Figure 8b the reconstruction after 3-level decomposition with removal of $H1_v$, $H1_h$, and $H1_{hv}$ along with the coarse block; and Figure 8c the reconstruction after 5-level decomposition with removal of $H1_v$, $H1_h$, and $H1_{hv}$ along with the coarse block. The corresponding line profiles are shown in Figures 9a, b,c, respectively. It should be clear from the line profiles that the two "blips" representing the small defects are more readily apparent with a 5-level decomposition.

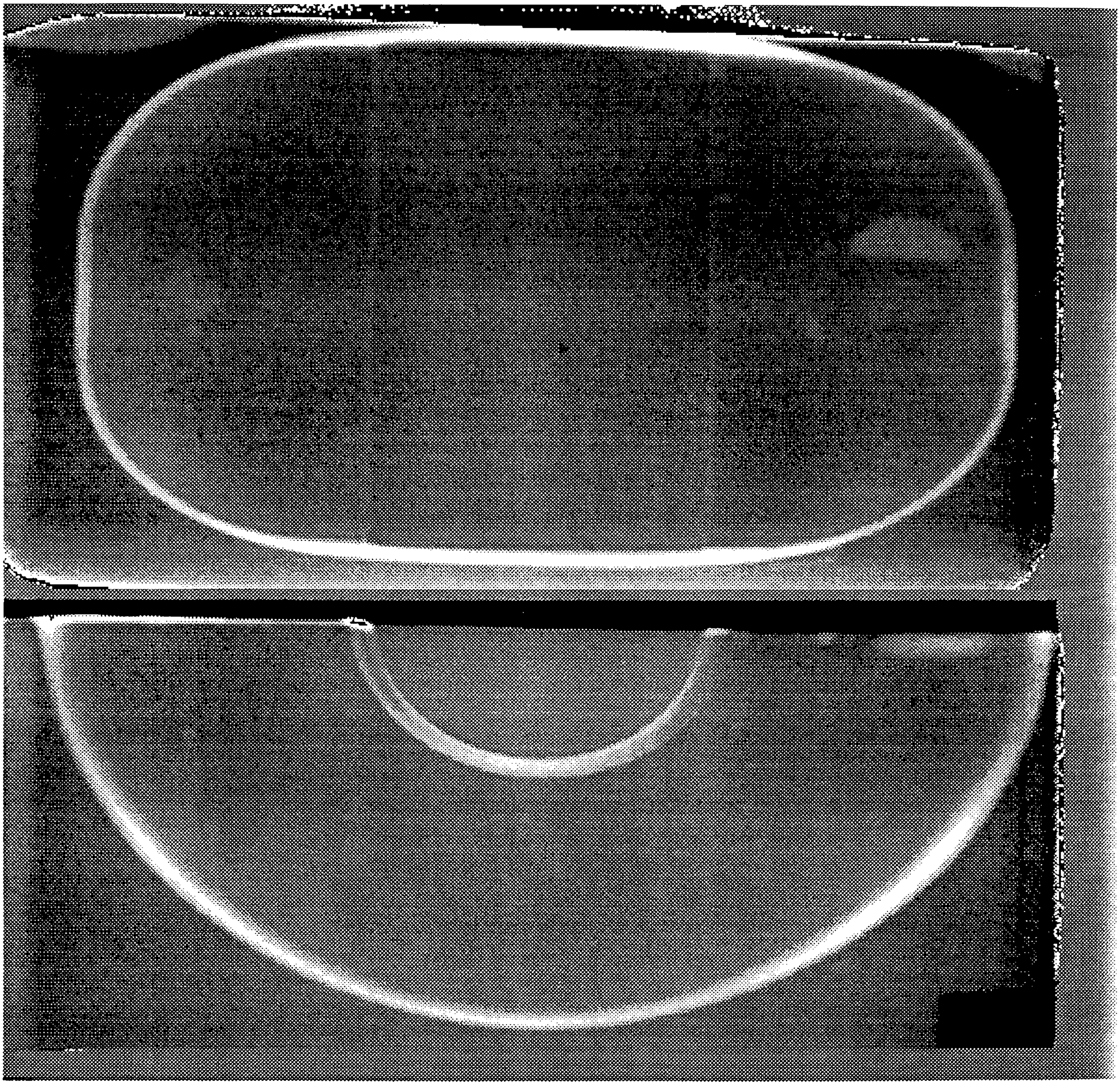


Figure 6a. Original Casting Image (Grain1405); with Large Defect in Upper Right

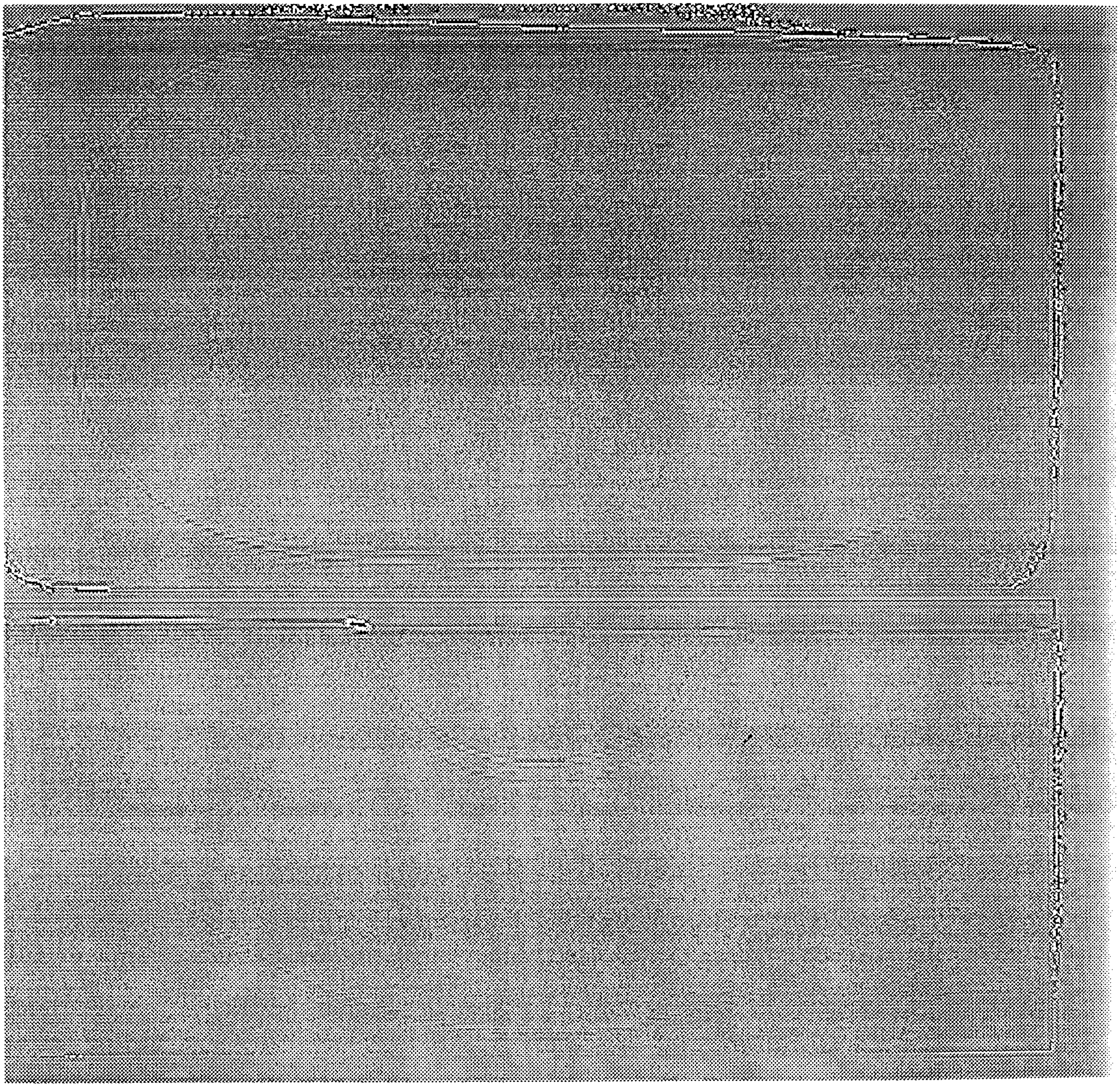


Figure 6b. One Level Decomposition; Reconstruction using $H1_v$, $H1_h$ and $H1_{hv}$ <u>only</u>

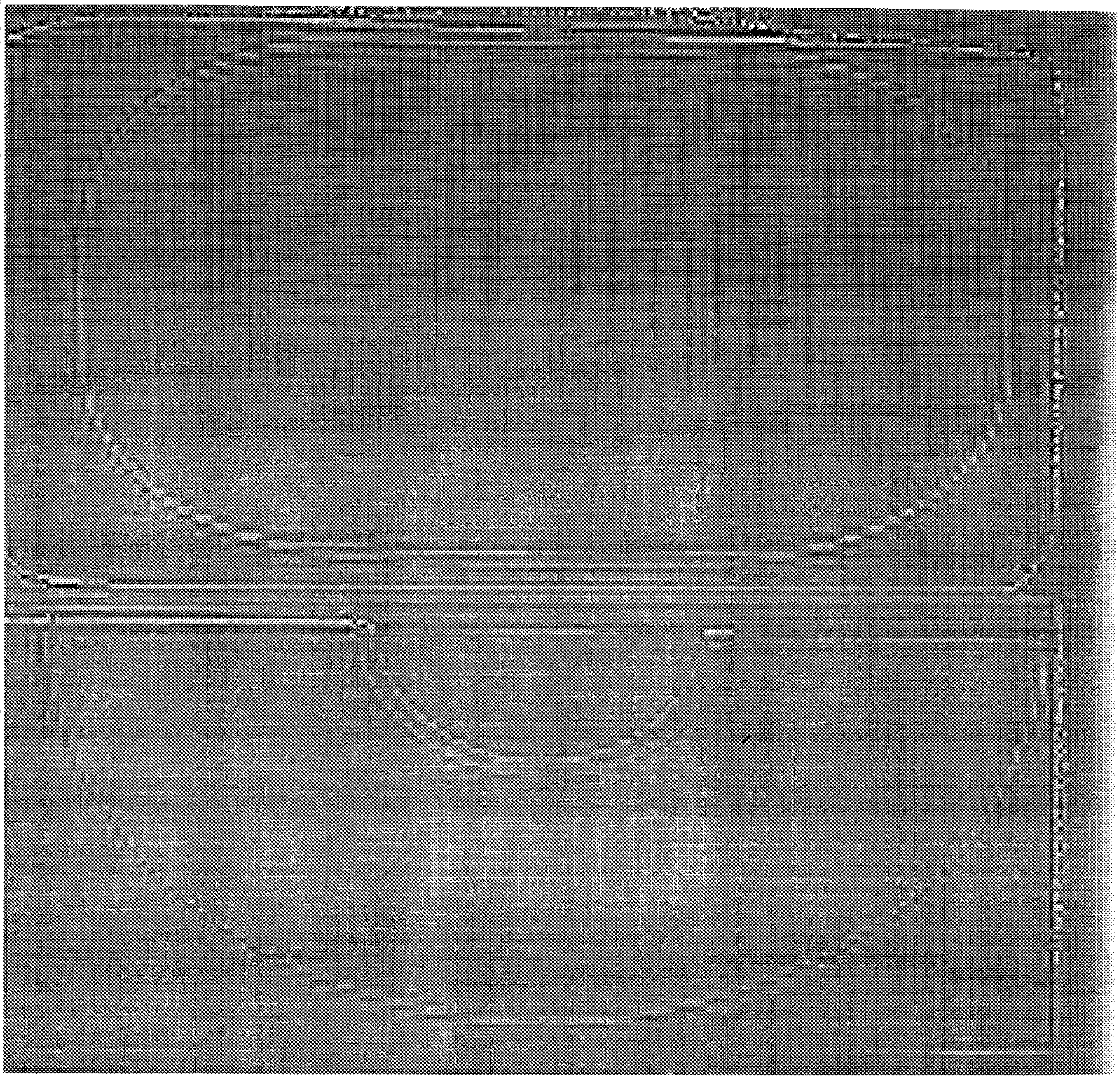


Figure 6c. Two Level Decomposition; Reconstruction using $H2_v$, $H2_h$ and $H2_{hv}$ only

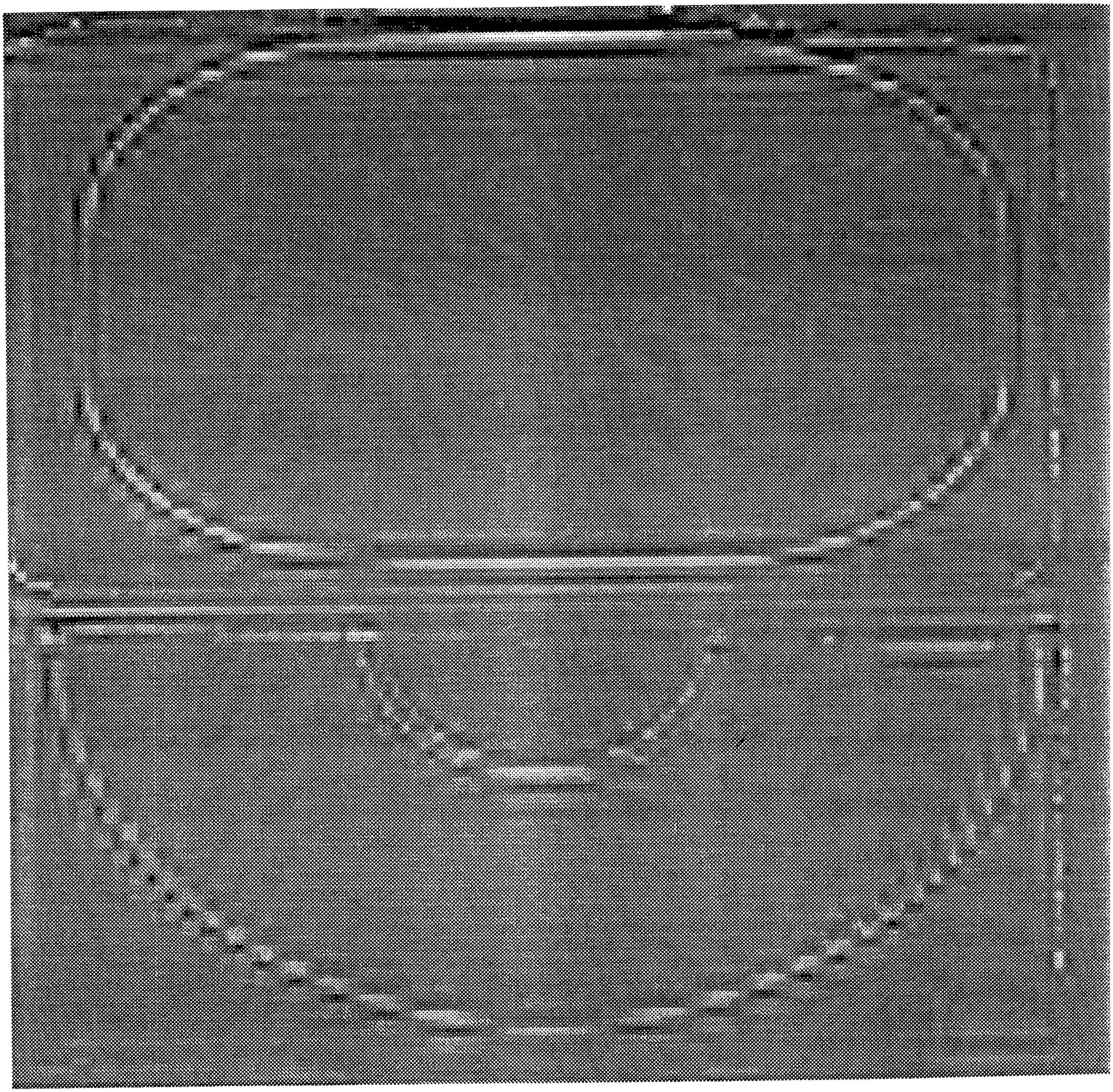


Figure 6d. Three Level Decomposition; Reconstruction using $H3_v$, $H3_h$ and $H3_{hv}$ only

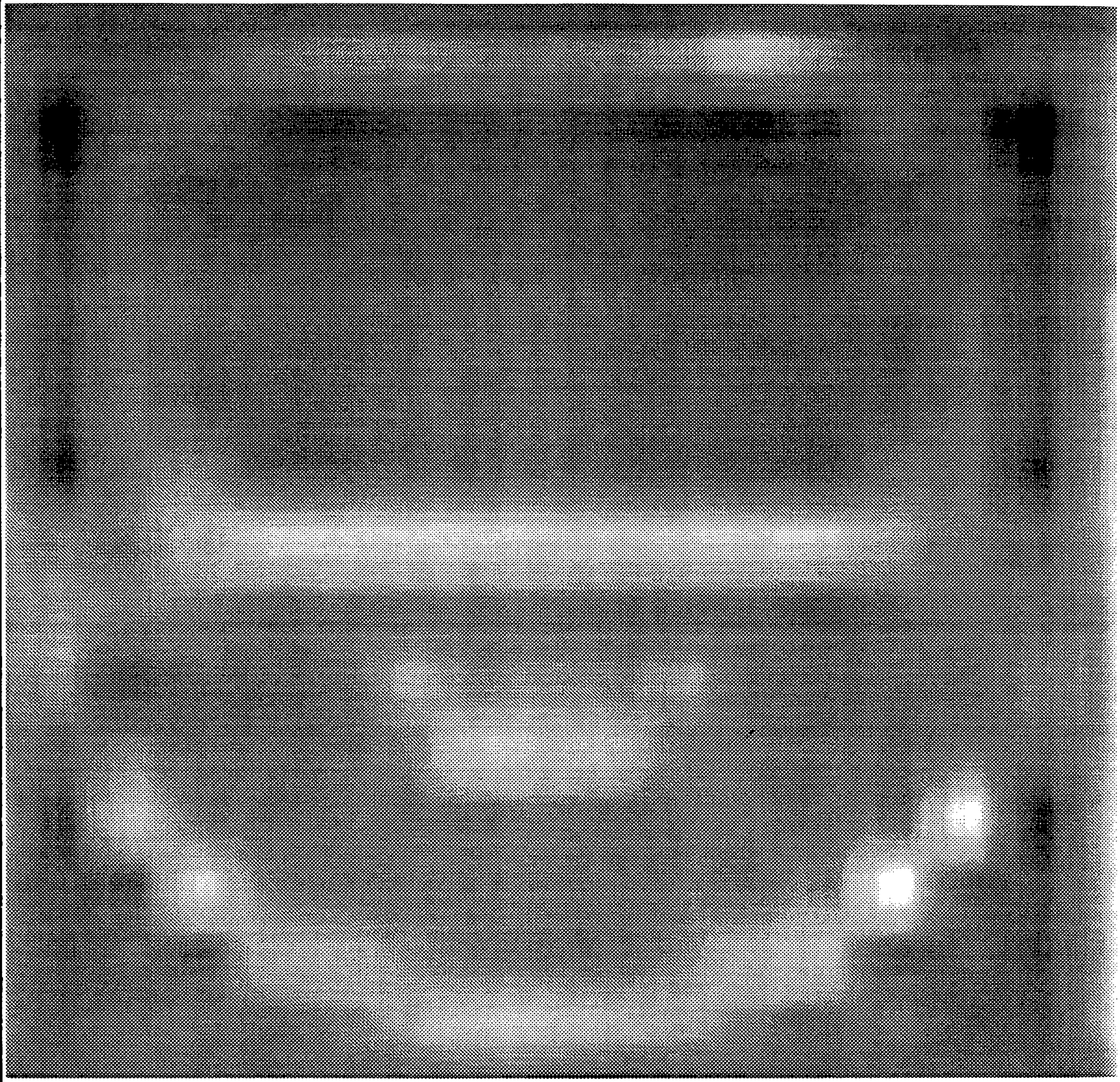
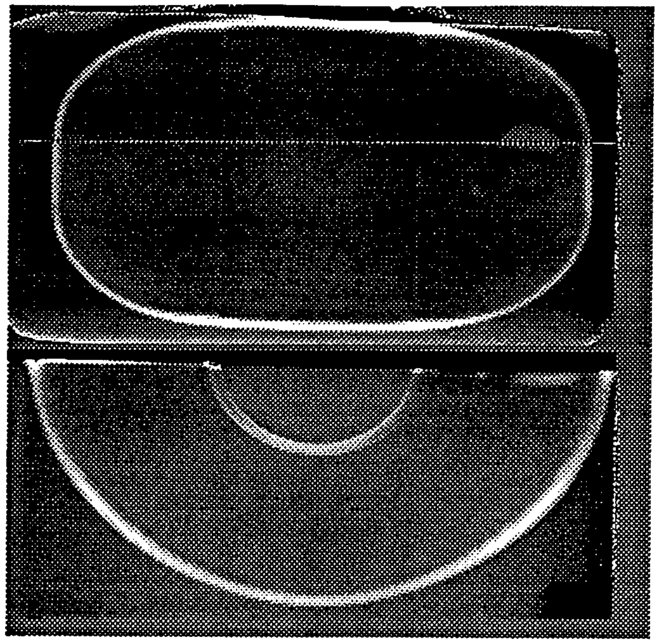


Figure 6e. Five Levels of Decomposition Followed by Reconstruction of Coarse Block Only



Line Profile

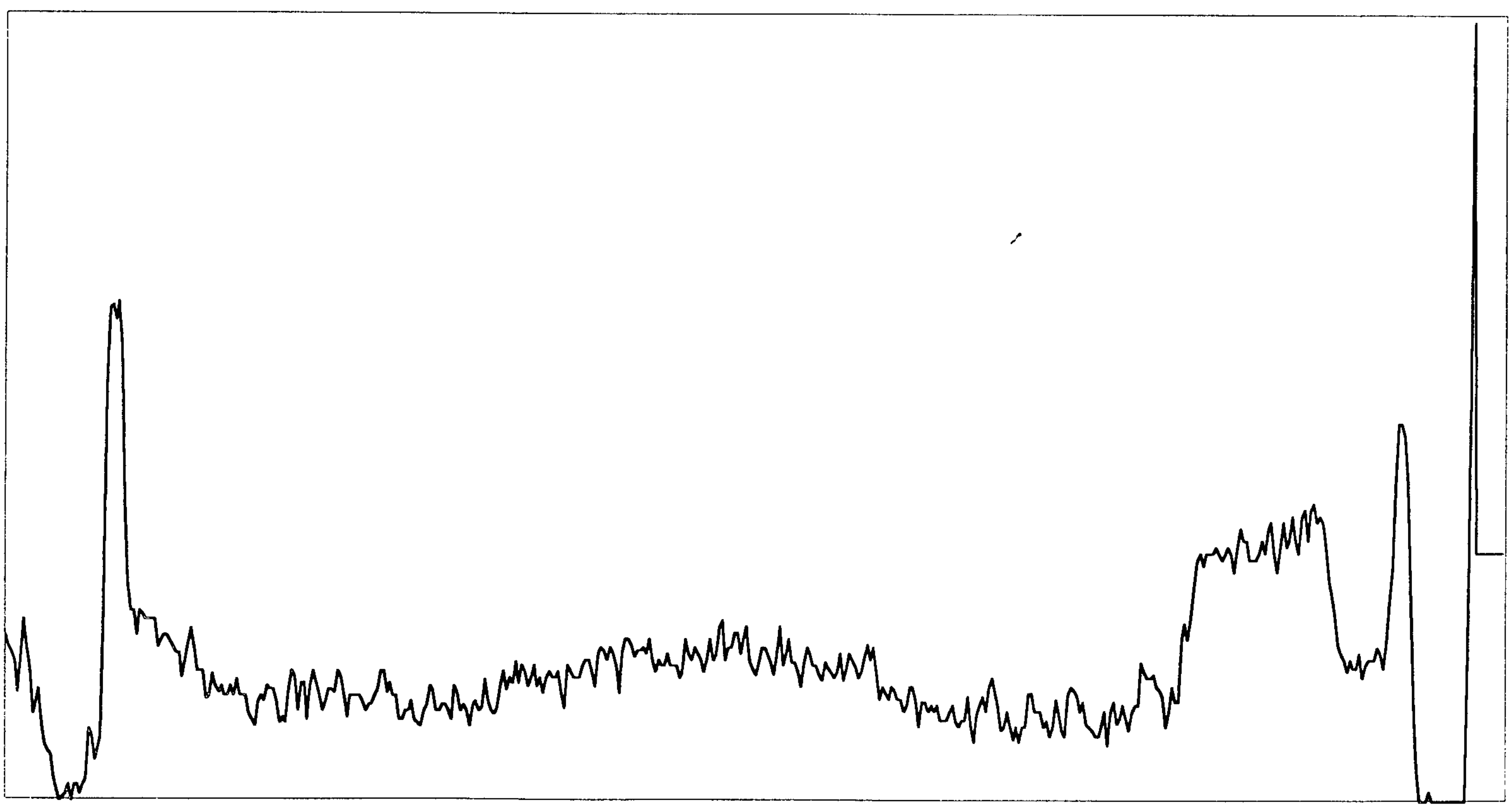
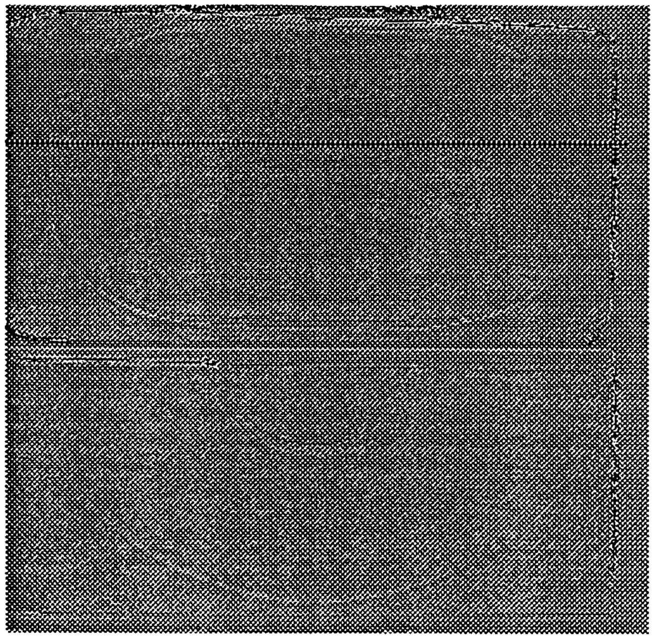


Figure 7a. Line Profile of Row Highlighted Above Corresponding to Figure 6a



Line Profile

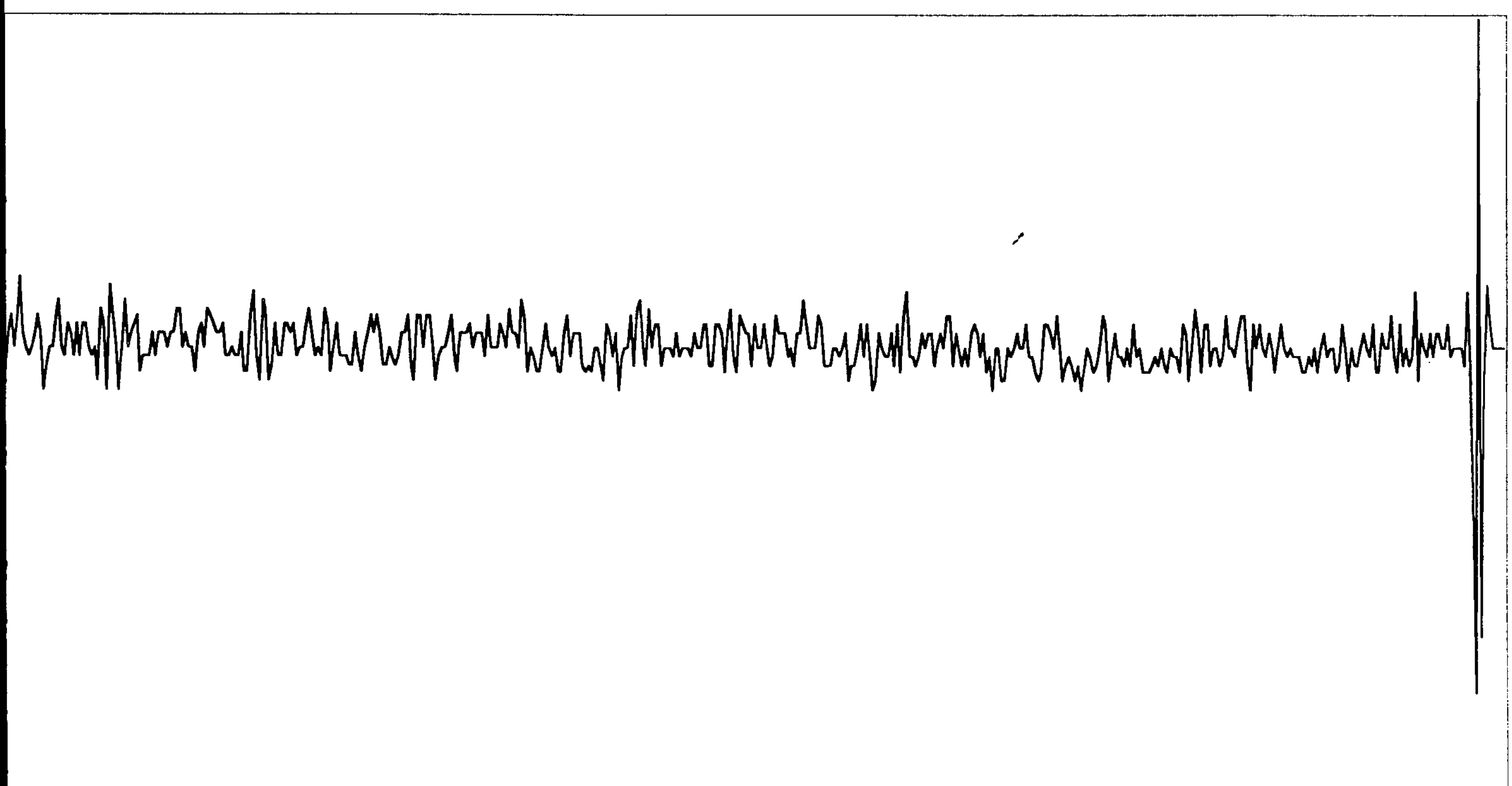
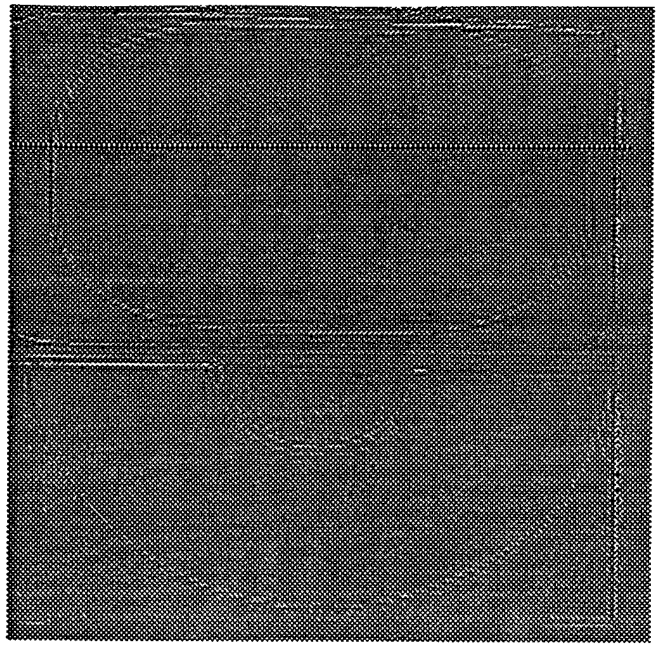


Figure 7b. Line Profile of Row Highlighted Above Corresponding to Figure 6b



Line Profile

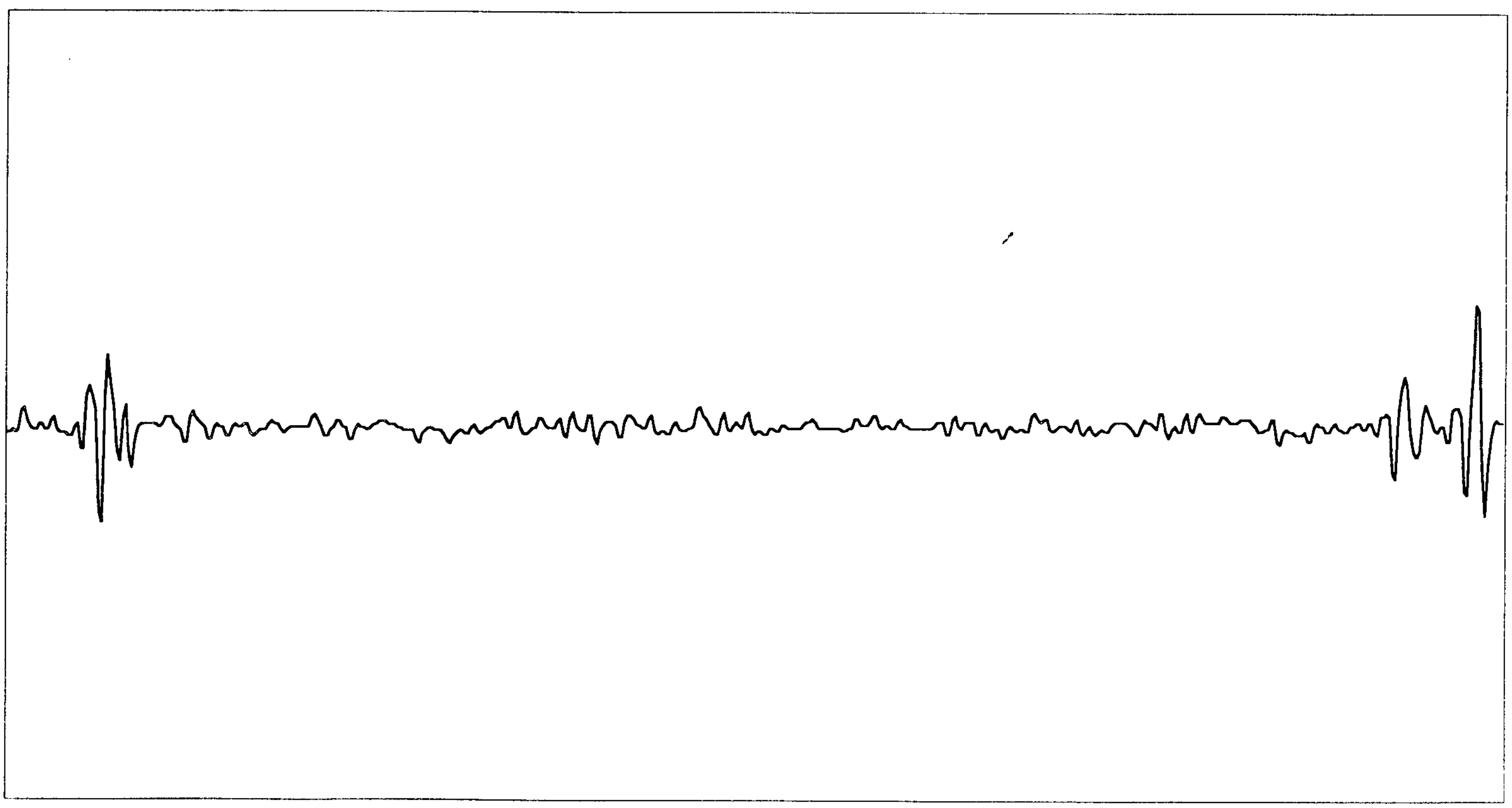
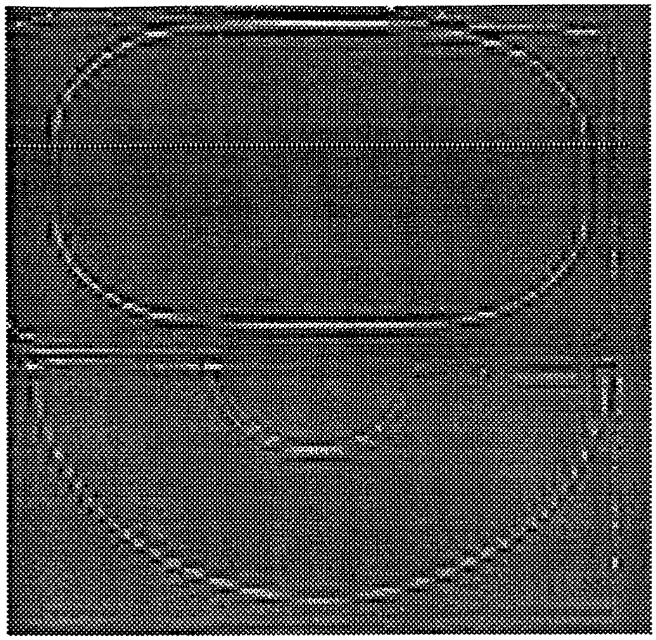


Figure 7c. Line Profile of Row Highlighted Above Corresponding to Figure 6c



Line Profile

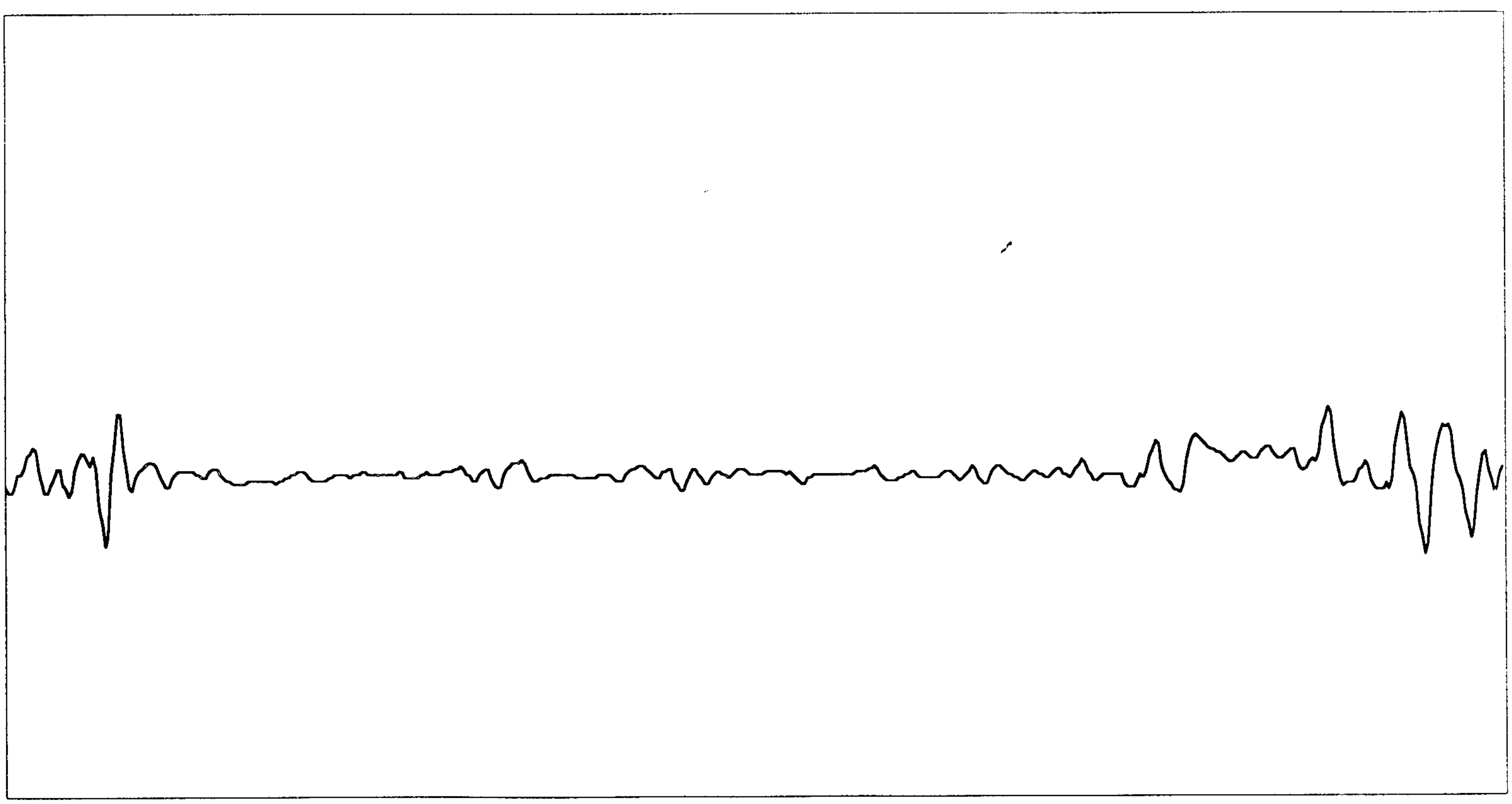
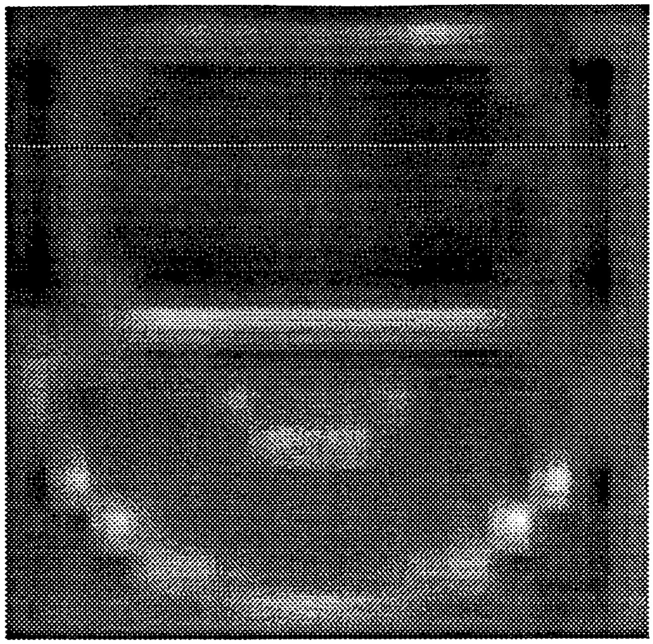


Figure 7d. Line Profile of Row Highlighted Above Corresponding to Figure 6d



Line Profile

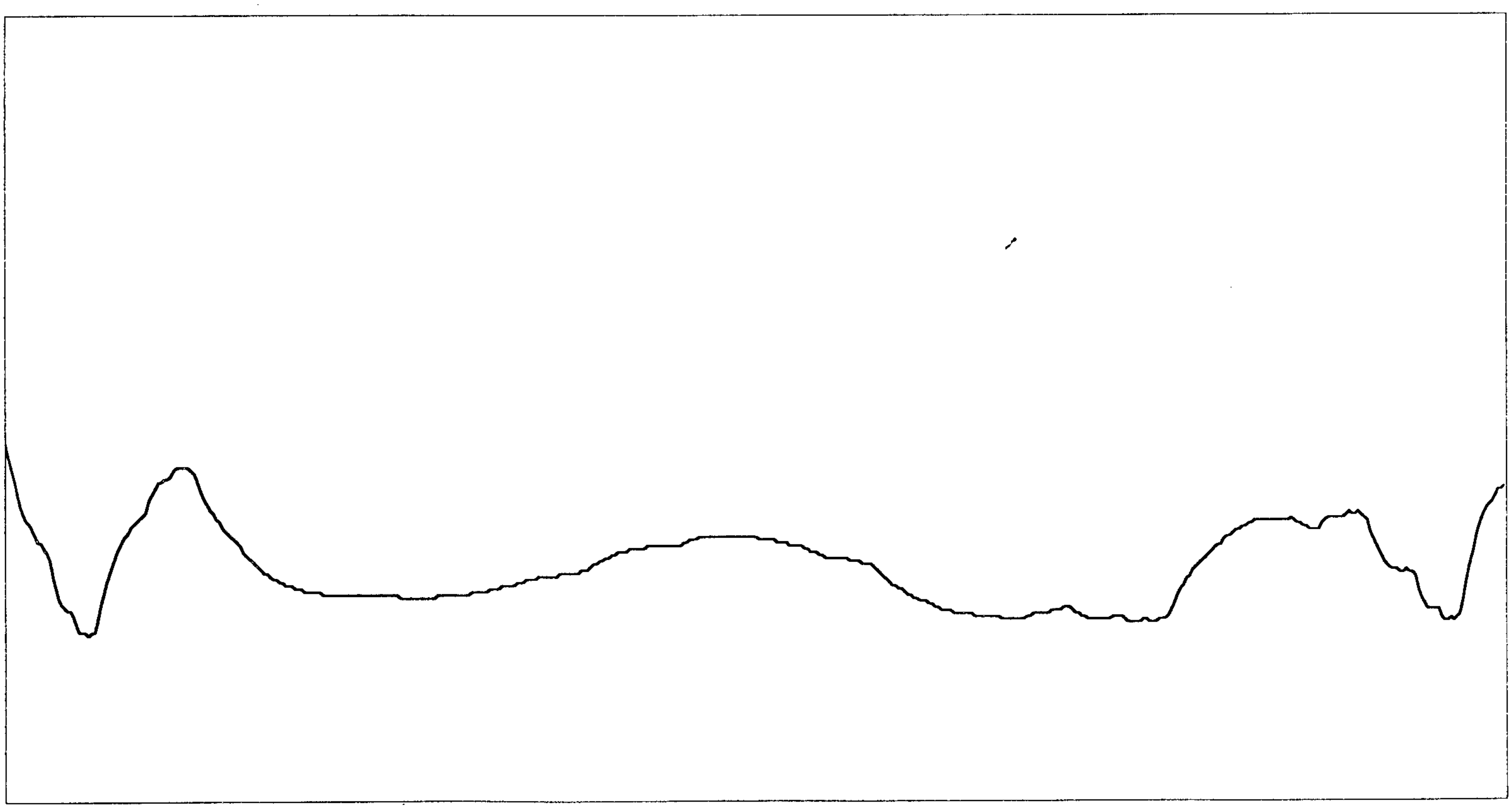


Figure 7e. Line Profile of Row Highlighted Above Corresponding to Figure 6e

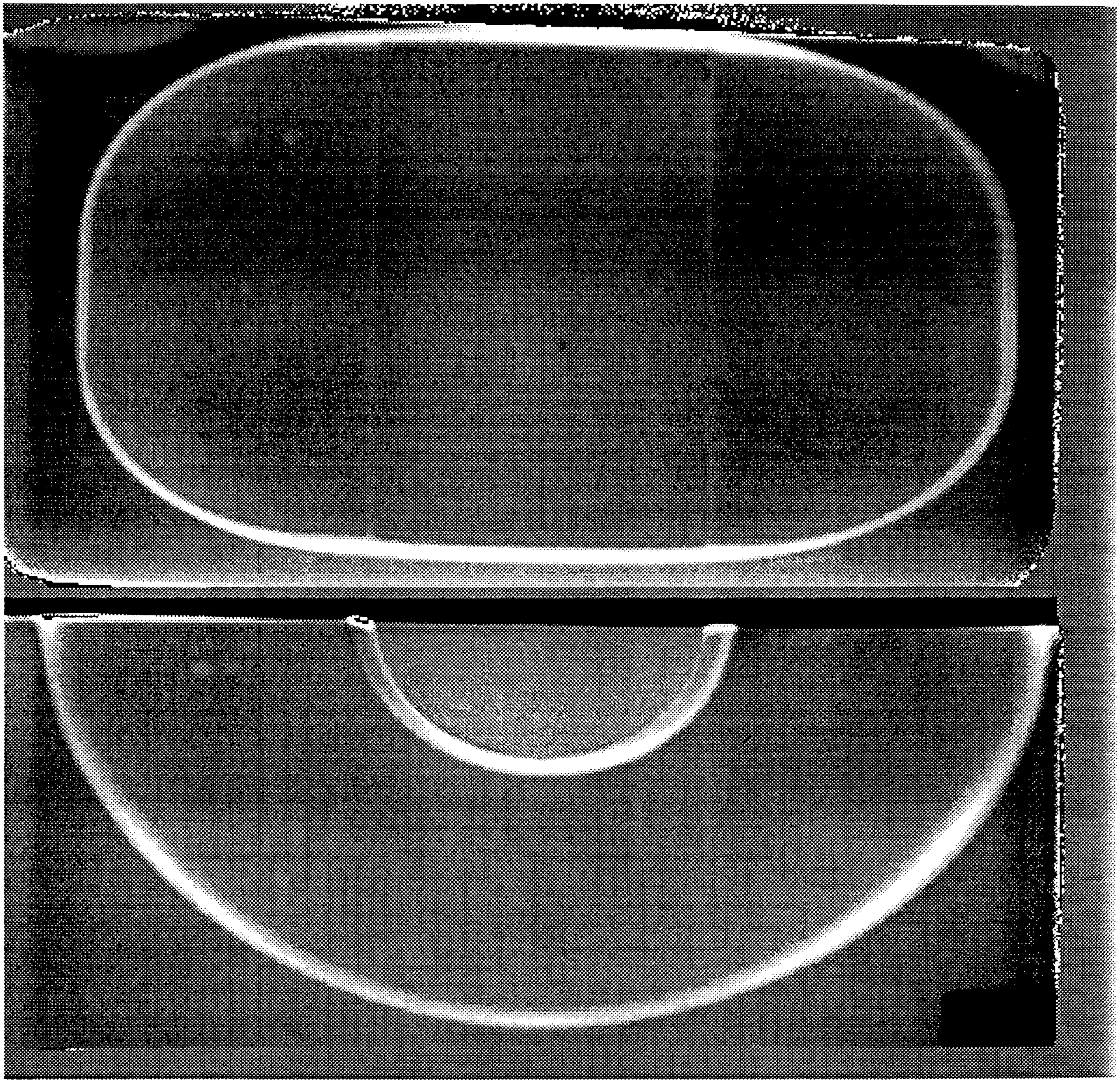


Figure 8a. Original Casting Image (Grain0002)

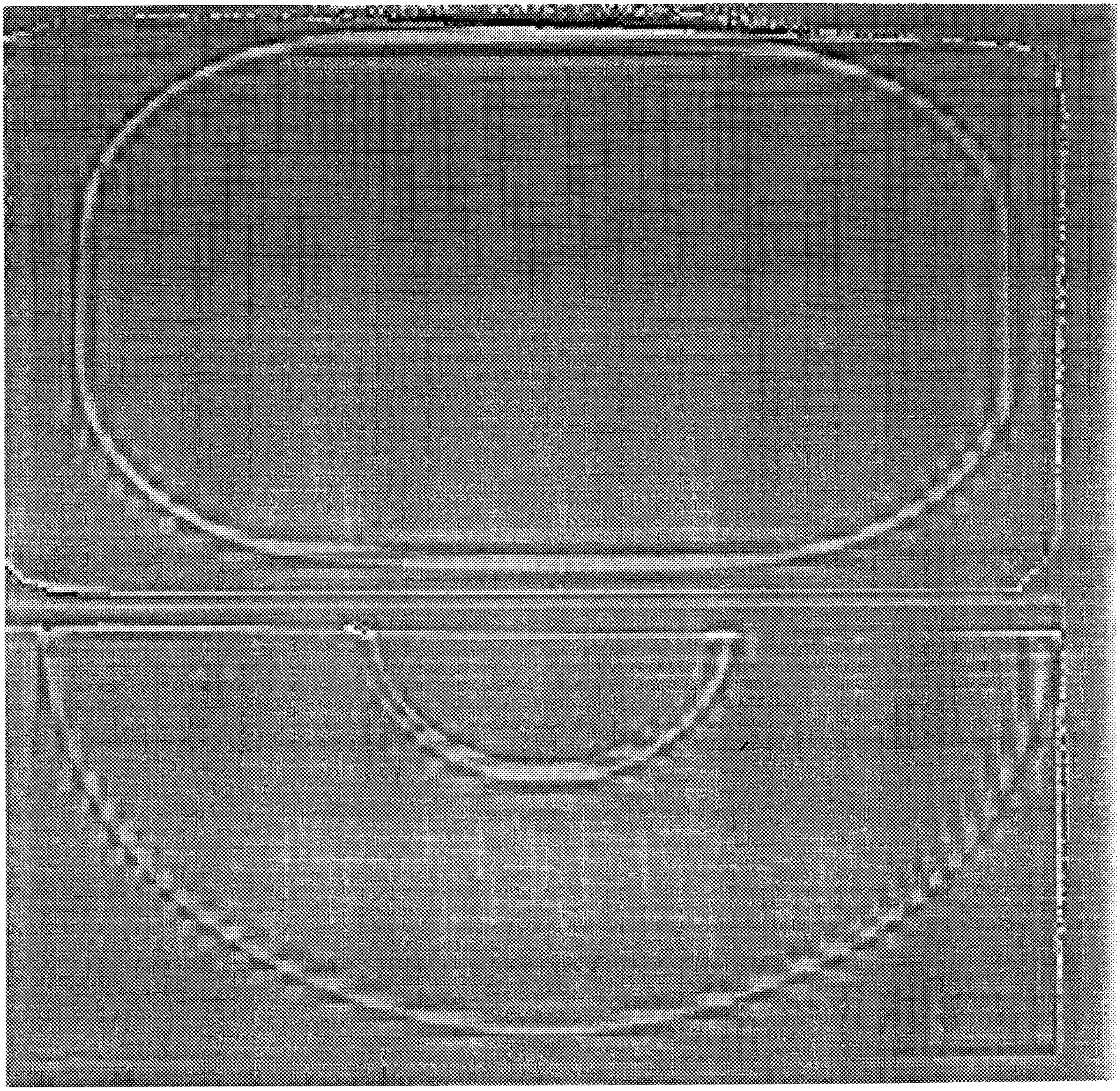


Figure 8b. Three Level Decomposition; Reconstruction <u>Excluding</u> $H1_v$, $H1_h$ and $H1_{hv}$ and Coarse Block

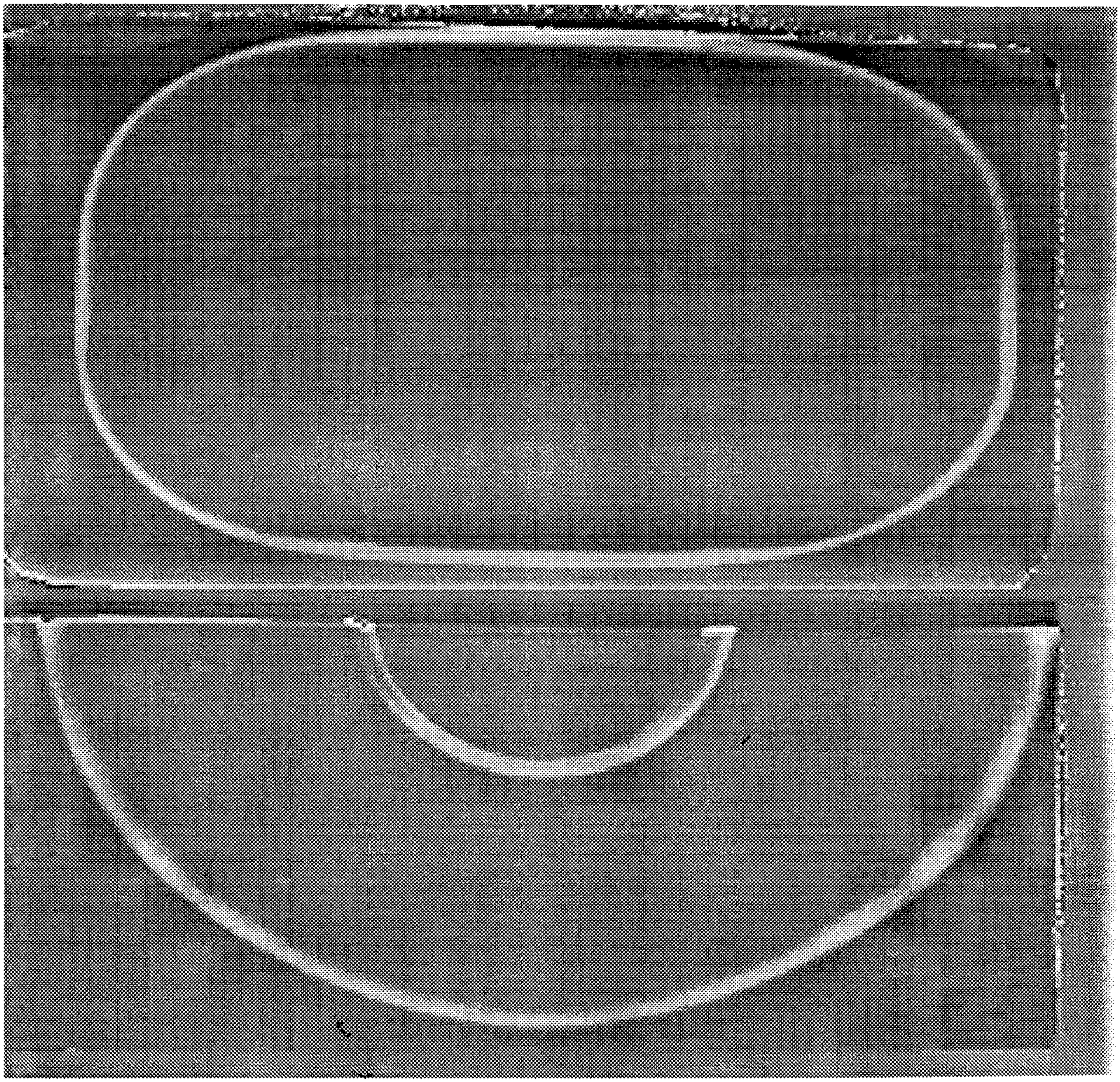
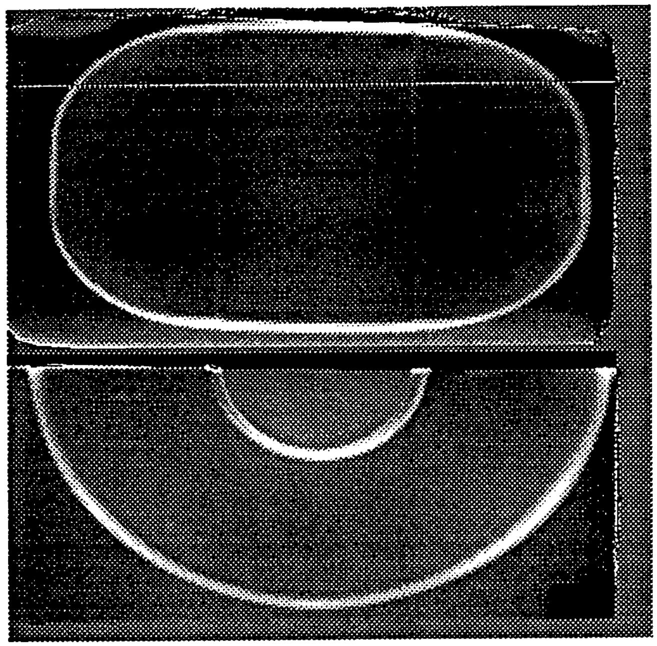


Figure 8c. Five Level Decomposition; Reconstruction <u>Excluding</u> $H1_v$, $H1_h$ and $H1_{hv}$ and Coarse Block



Line Profile

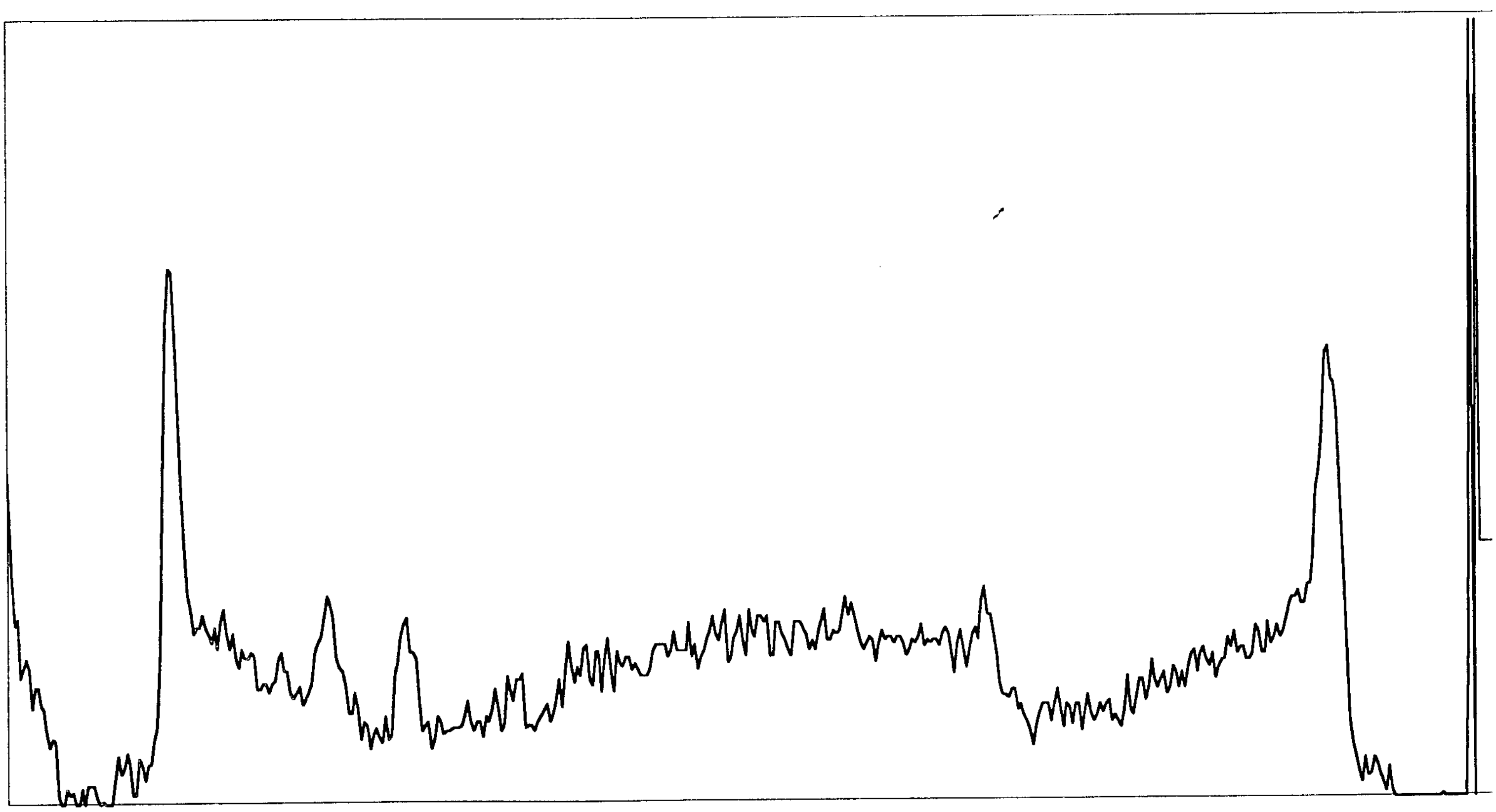
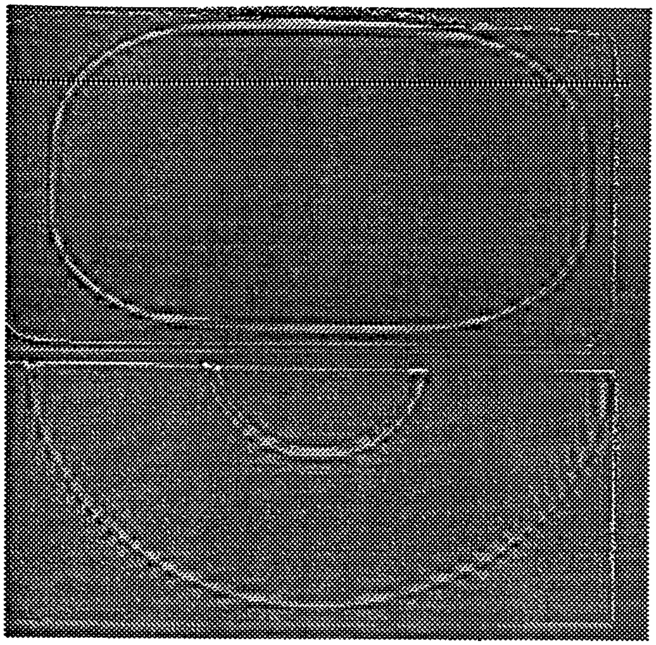


Figure 9a. Line Profile of Casting Image Sequence Corresponding to Figure 8a



Line Profile

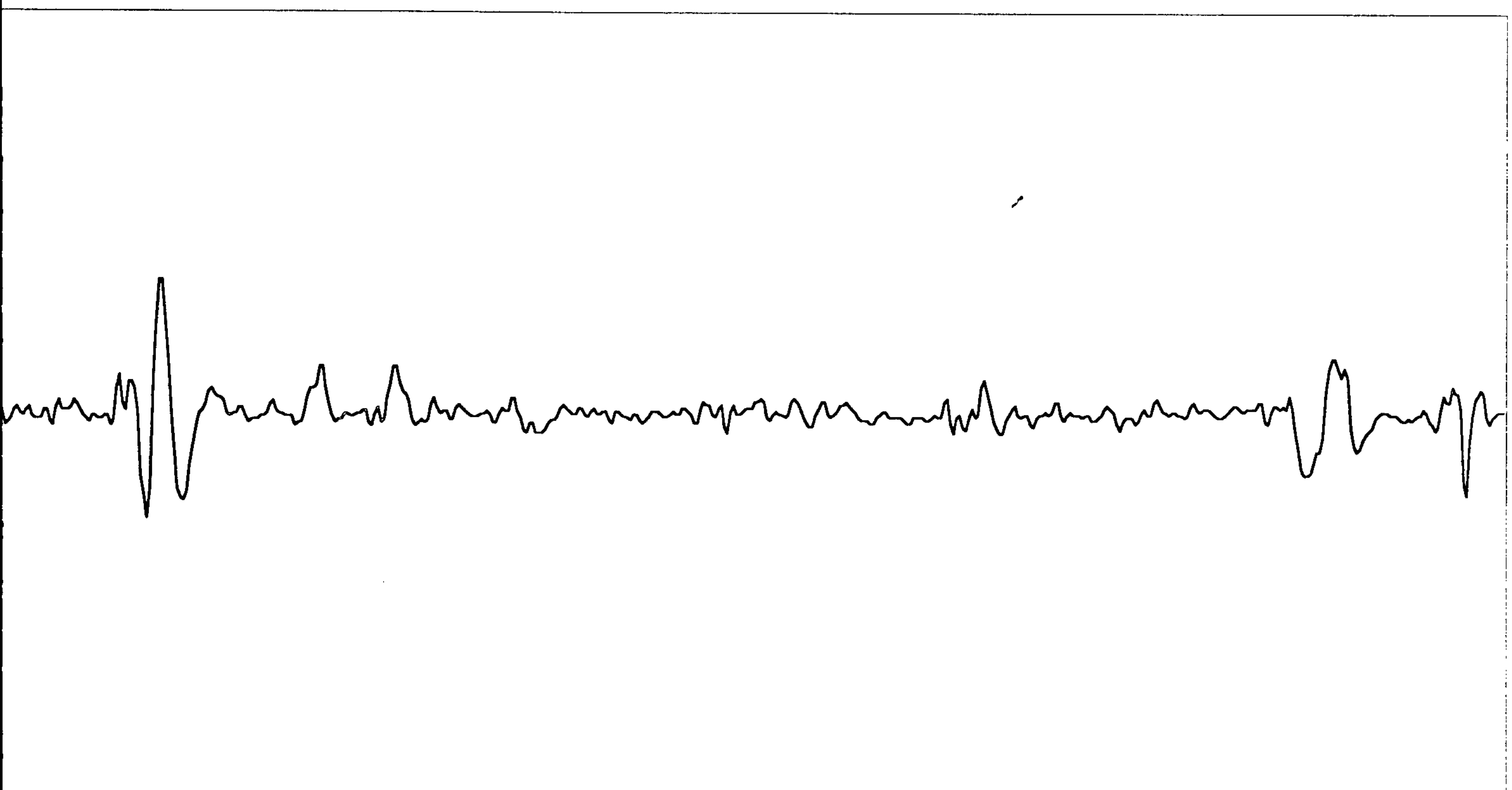
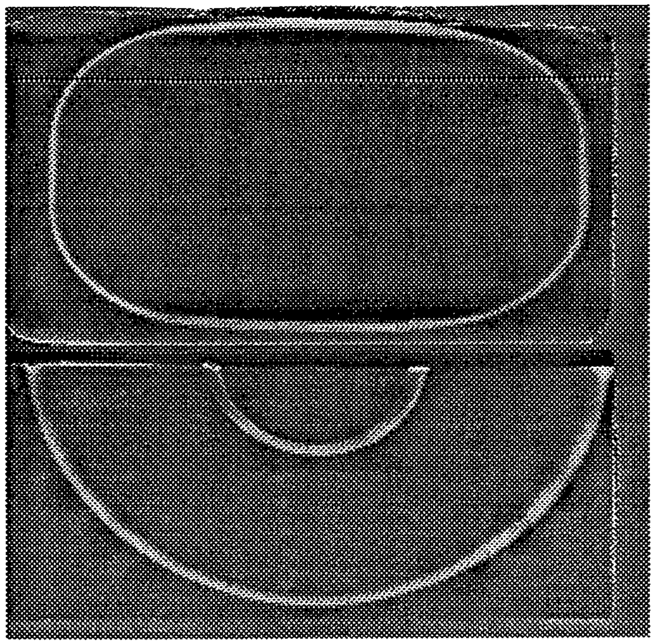


Figure 9b. Line Profile of Casting Image Sequence - Corresponding to Figure 8b



Line Profile

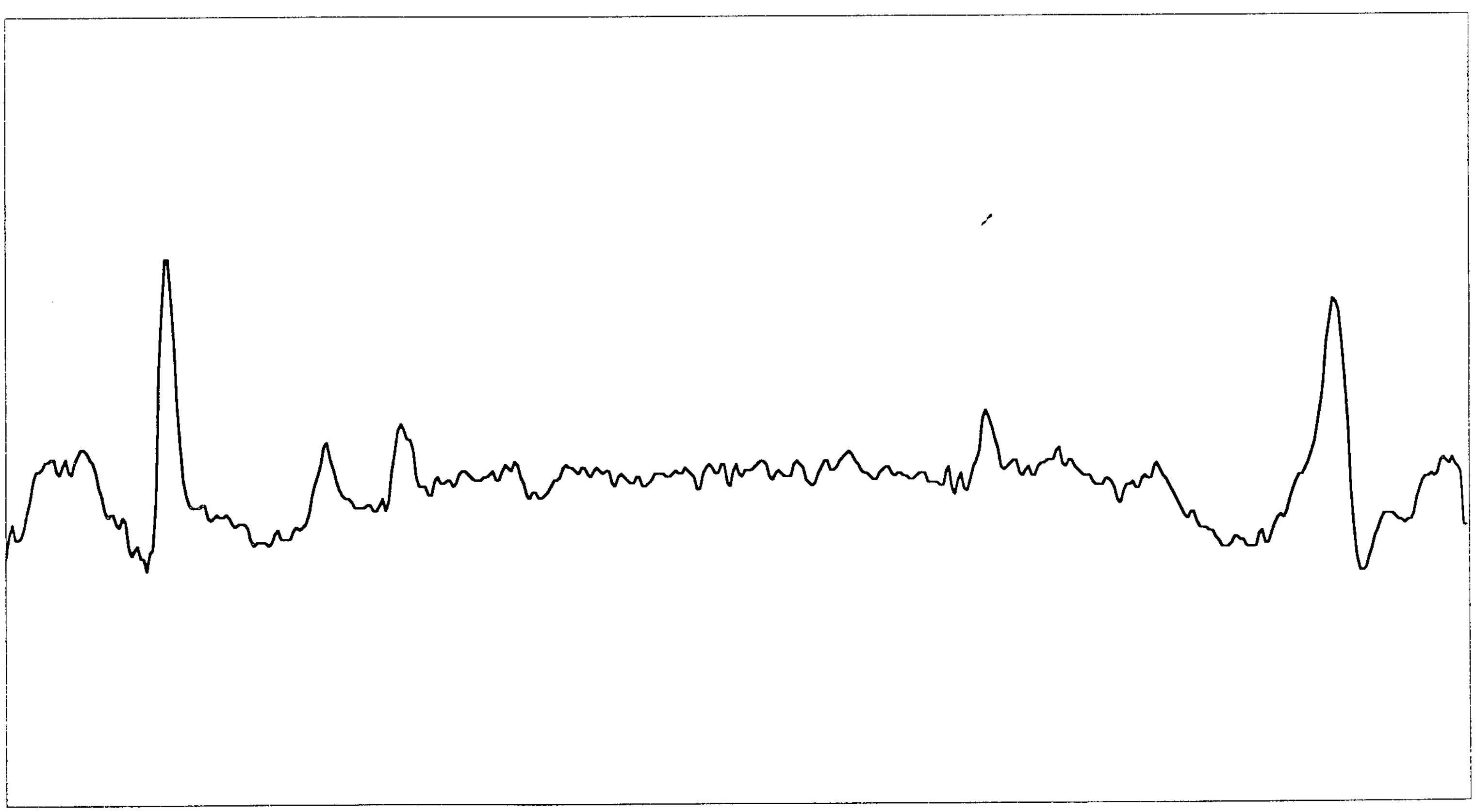


Figure 9c. Line Profile of Casting Image Sequence - Corresponding to Figure 8c

The same experiments were done on image "grain1405" and are shown in Figures 10a, b and 11a,b, respectively. Notice that with only 3-levels, the large defect has effectively been removed which is consistent with the multiresolution discussion above.

II.3.1.1.2 Wavelet Taps

Next, we investigated the effect of increasing the number of "taps" for a given wavelet. Within each family of wavelets, such as the Daubechies family, are wavelet subclasses distinguished by the number of coefficients and by the level of iteration. Wavelets are classified within a family most often by the *number of vanishing moments.* The higher the number of taps, the higher the number of coefficients. This is an extra set of mathematical relationships for the coefficients that must be satisfied, and is directly related to the number of coefficients. The larger the number of taps, the smoother the results. The grain0002 image with three small defects was filtered by the Daubechies-4 (4 taps) and Daubechies-20 (20 taps) wavelets and, in both cases, the three high frequency components and the low frequency components were removed and reconstructed. Figures 12a and b show the reconstructed images; Figures 13a and b the line profiles. As is evident from the line profiles, the higher the taps, the smoother the result. However, more taps mean significantly increased computation time.

II.3.1.1.3 Mother Wavelet Selection

The choice of a mother wavelet for Phase I required considerable investigation. While we are satisfied with the results of the propellant cast analyses, mother wavelet selection/determination should be one of the central themes of a Phase II effort. In the Phase I effort we only concentrated on discrete separable wavelets. Implementation was straightforward and compute times were short. In the Phase I proposal, we had discussed using an existing wavelet in the public domain, the Mallat 2-D wavelet. A survey of public domain wavelet applications afforded us an opportunity to try not only the Mallat Battle-Lemarie filter, but also the Burt-Adelson filter, the Coifflet (2, 4 & 6) filters, the Daubechies (2, 6, 8, 10, 12 & 20) filters, the Haar filter, the PseudoCoifflet filter and the Spline (2-2, 2-4, 3-3 & 3-7) filters. The code for each was incorporated as a DLL plug-in for ImageTool.

It is important to point out the differences in processing times and impact on the propellant images when comparing the various wavelets.

For the wavelets investigated, the same image (grain0002) was used each time, decomposed to 5 levels, and the three highest frequency coefficients ($H1_v$, $H1_h$, and $H1_{hv}$,) were removed as was the coarse block followed by image reconstruction. Figures 14a-e show filtering by the Mallat Battle Lemarie, Spline3-7, Spline2-2, Burt Adelson, and Haar wavelets. Figures 15a-e show the line profiles.

The Haar is too abrupt and "squared off" to be successful, the reconstructed image is blocky and not acceptable. The Burt Adelson revealed the defects nicely but introduced some noise bursts (not shown in the line profile) which may have been interpreted as anomalies in subsequent processing steps. The Spline3-7 brought out the defects better than the Spline-2

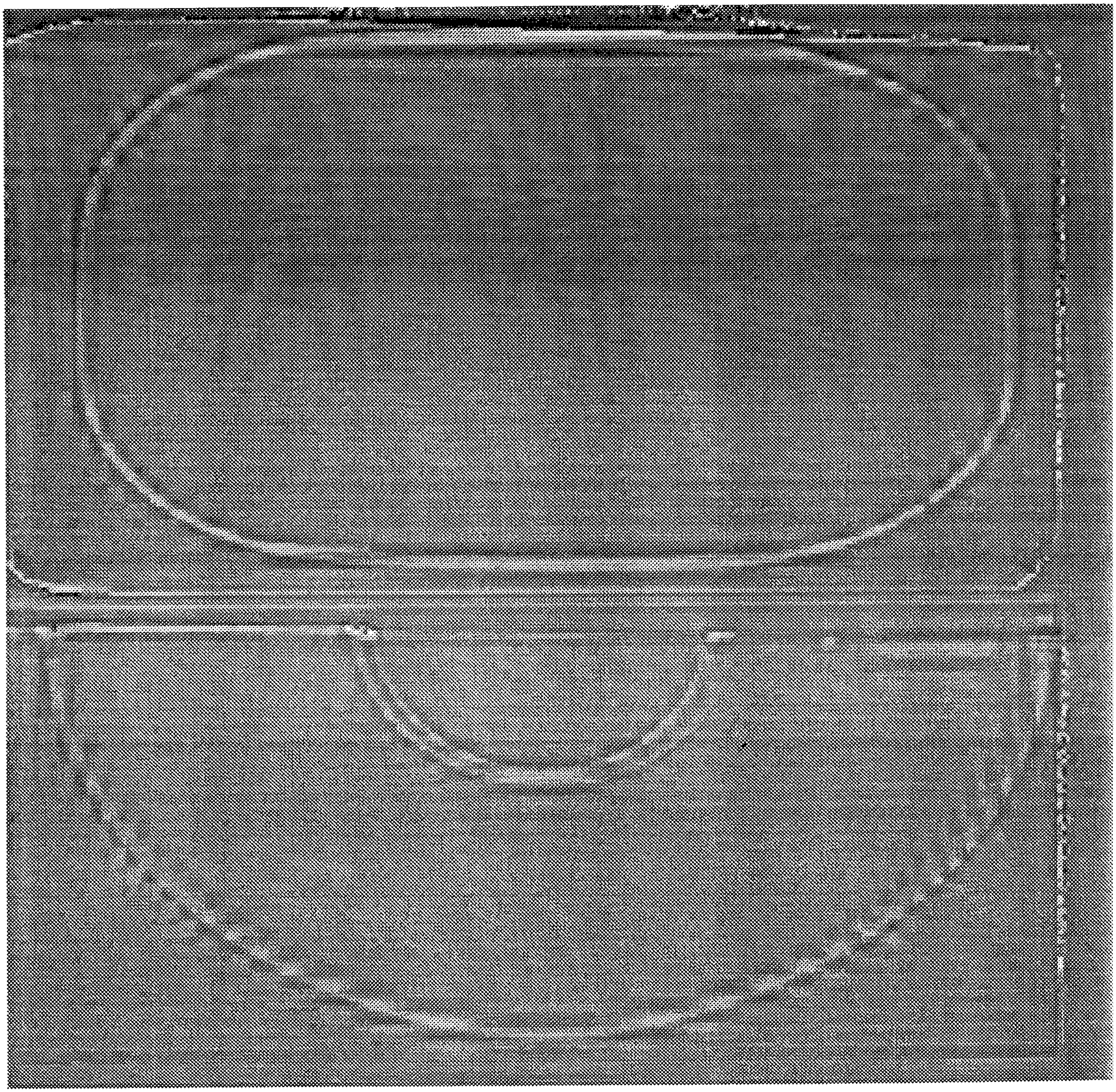


Figure 10a. Three Level Decomposition of Grain1405; Reconstruction Excluding $H1_v$, $H1_h$ and $H1_{hv}$ and Coarse Block

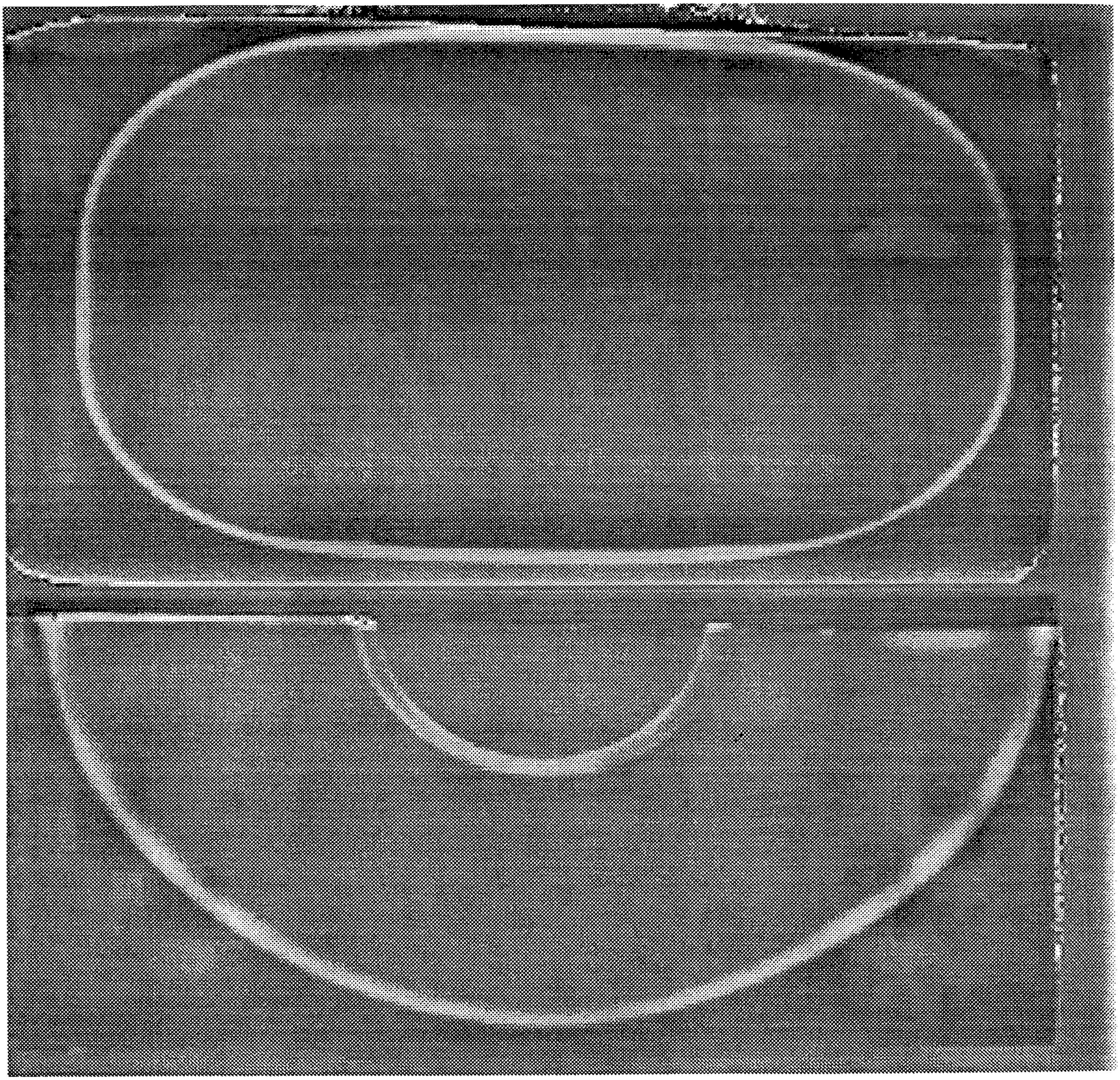
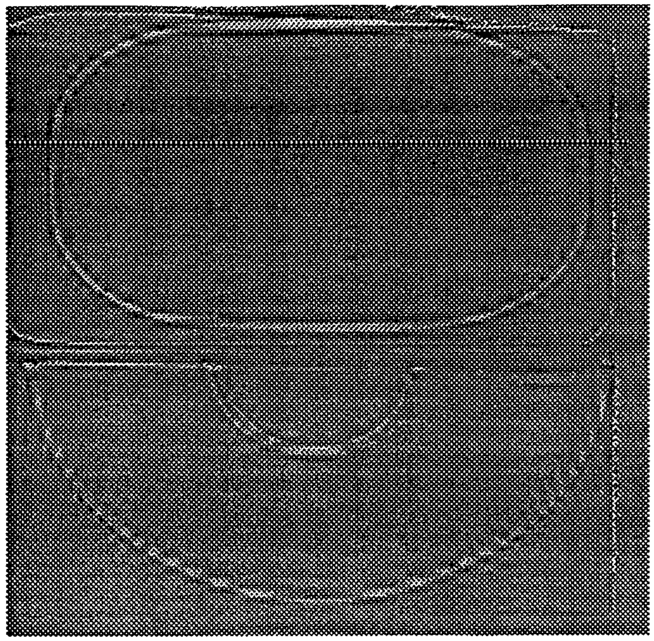


Figure 10b. Five Level Decomposition of Grain1405; Reconstruction Excluding $H1_v$, $H1_h$ and $H1_{hv}$ and Coarse Block



Line Profile

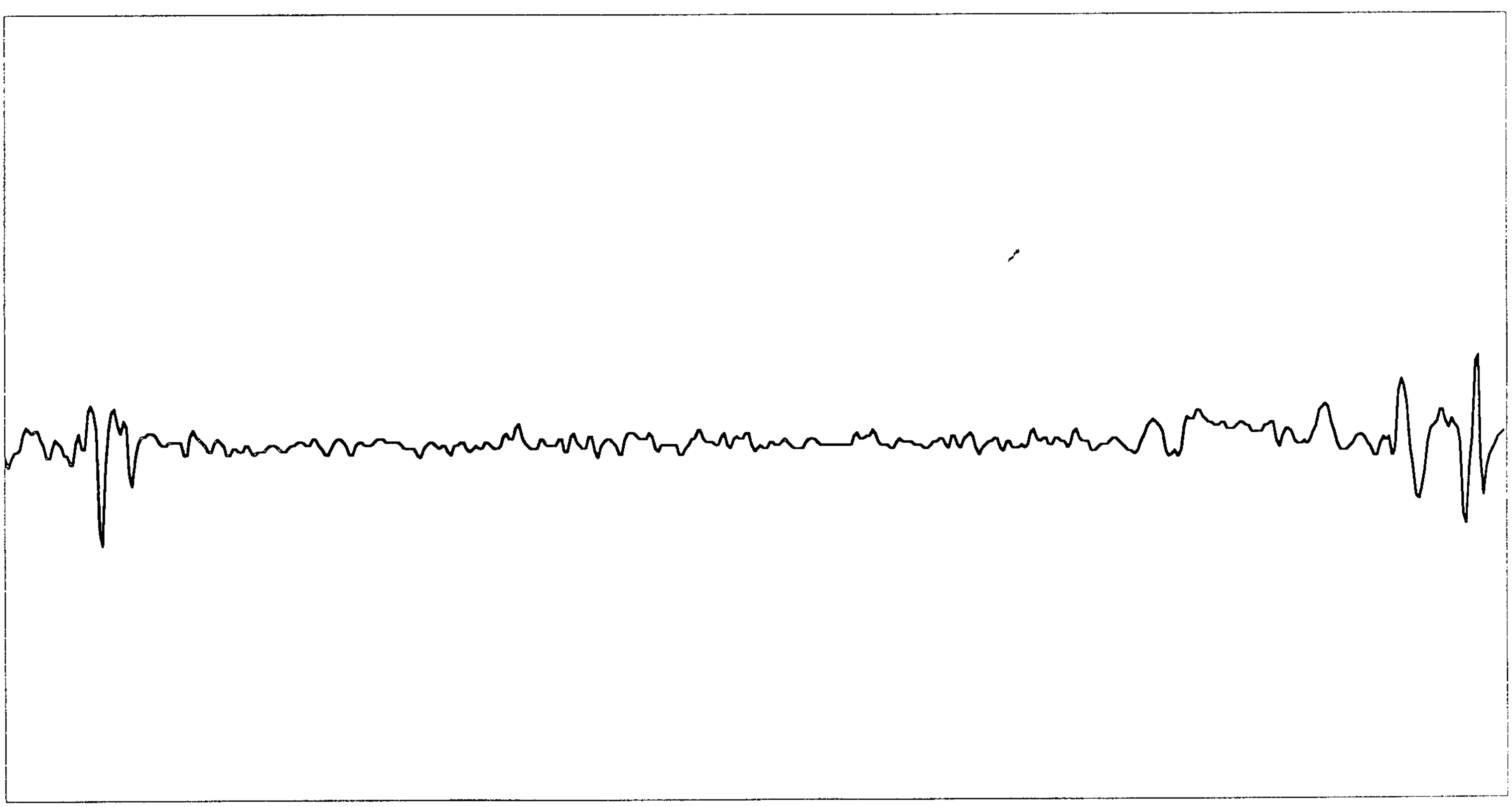
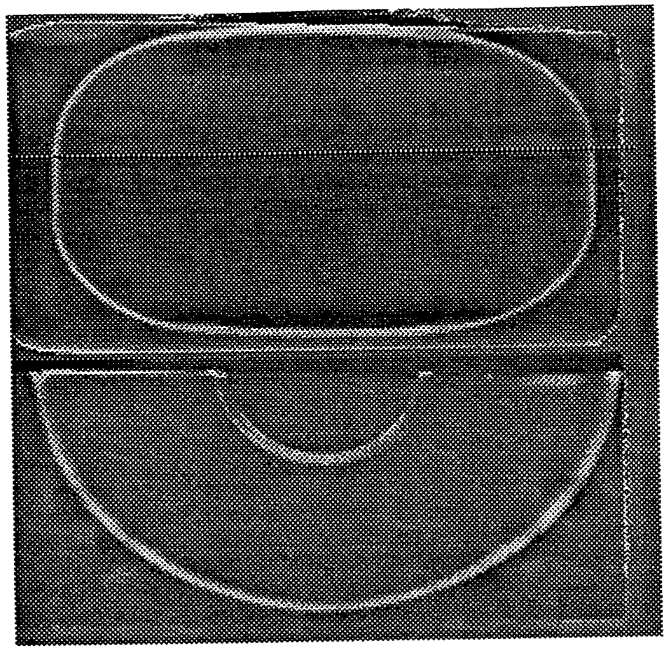


Figure 11a. Line Profile Corresponding to Figure 10a



Line Profile

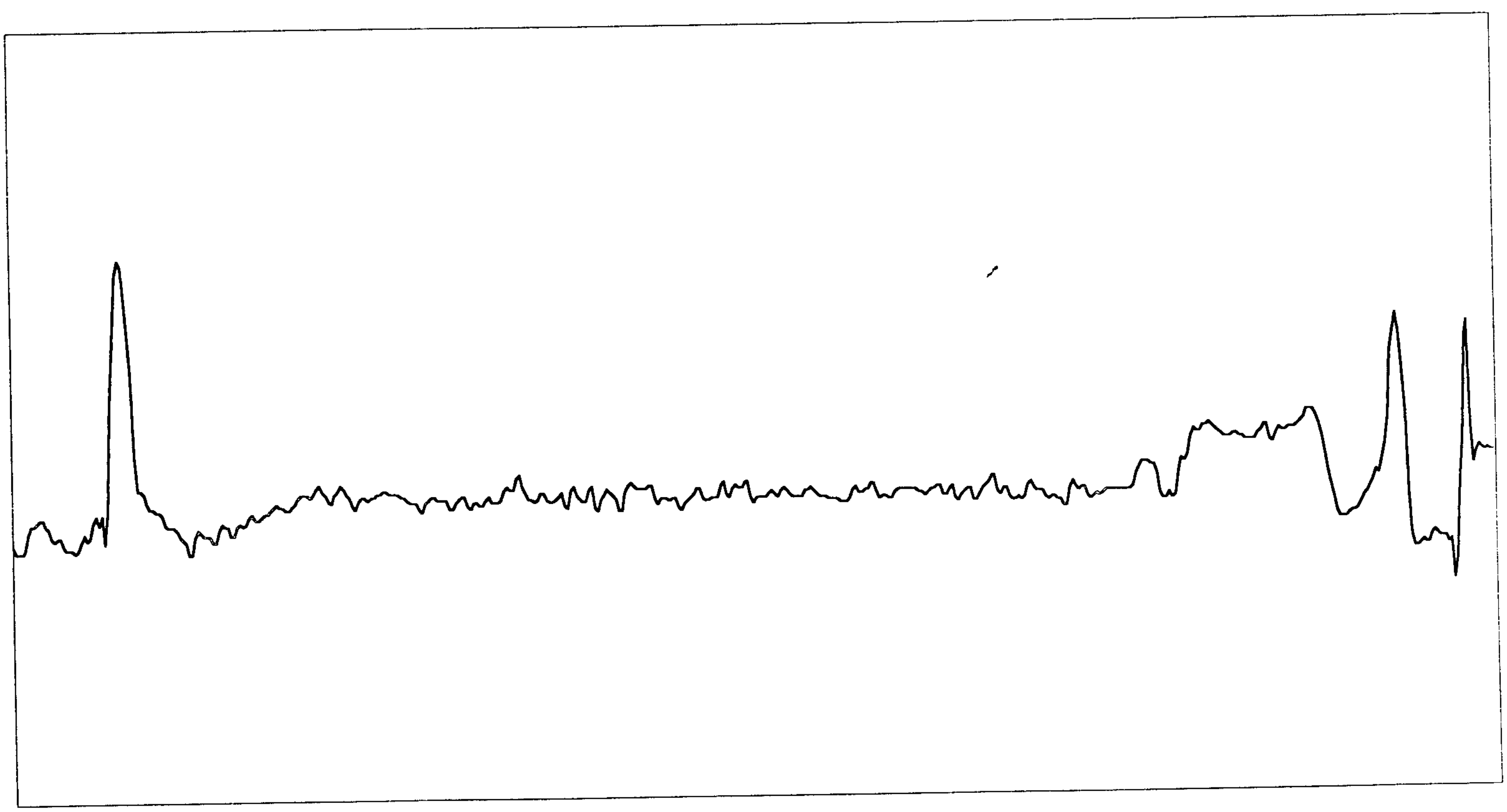


Figure 11b. Line Profile Corresponding to Figure 10b

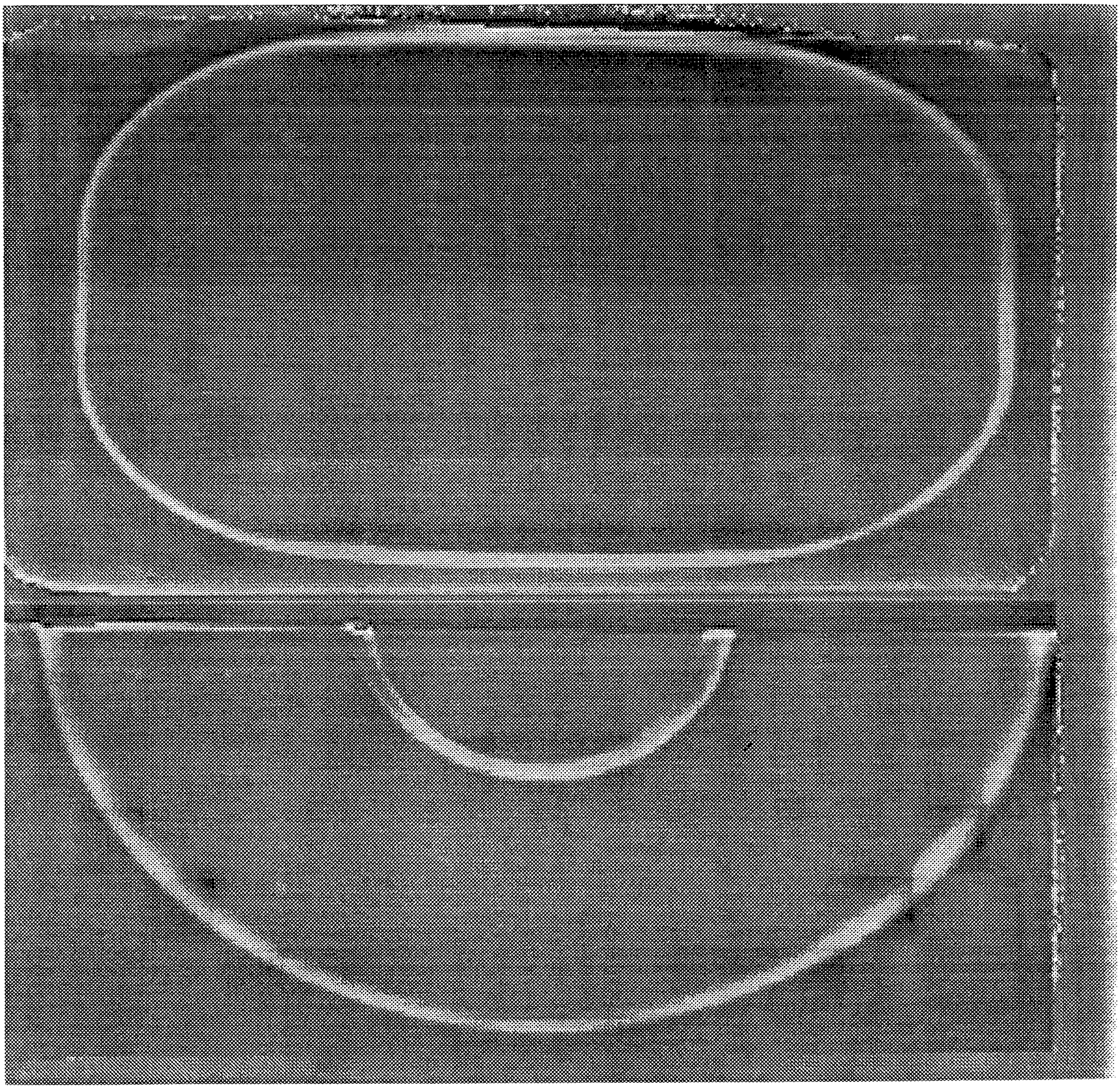


Figure 12a. Grain0002 Image with 3 Defects Filtered by Daubechies-4

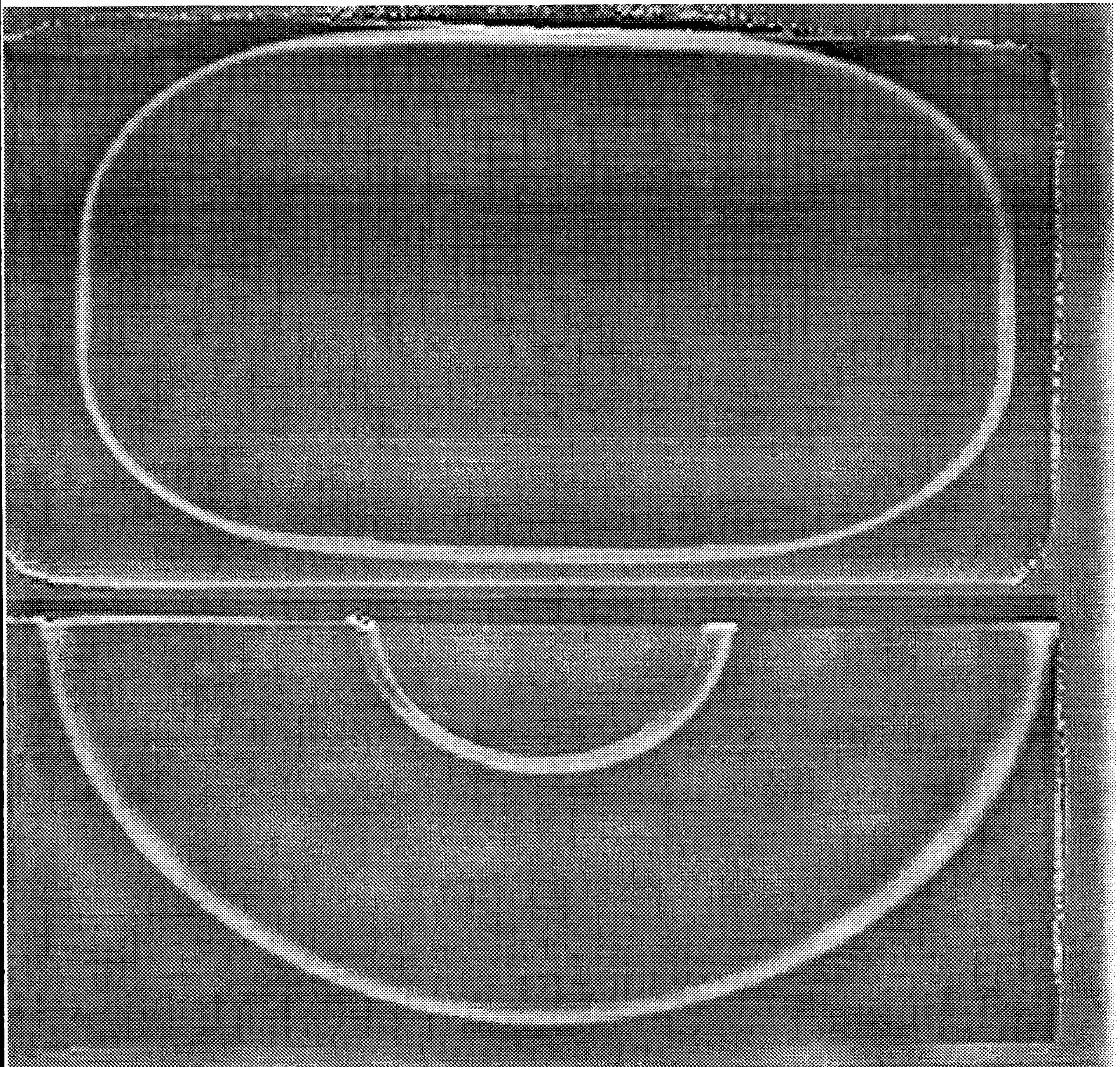
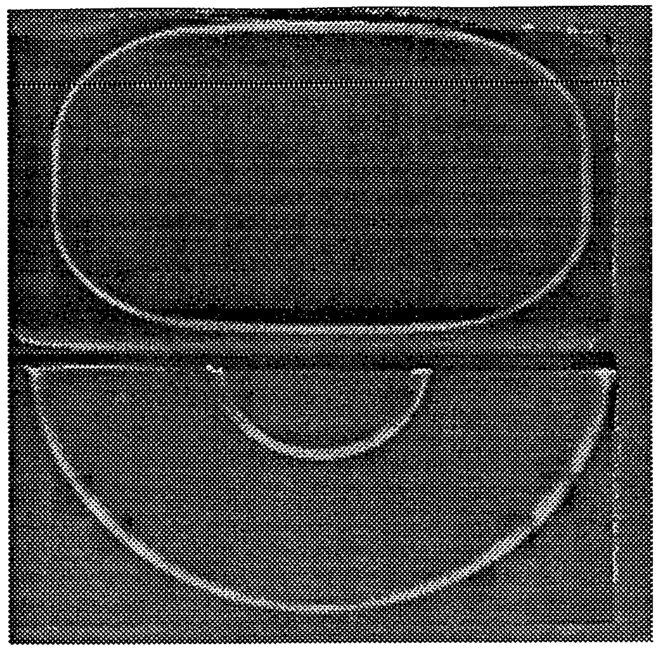


Figure 12b. Grain0002 Image with 3 Defects Filtered by Daubechies-20



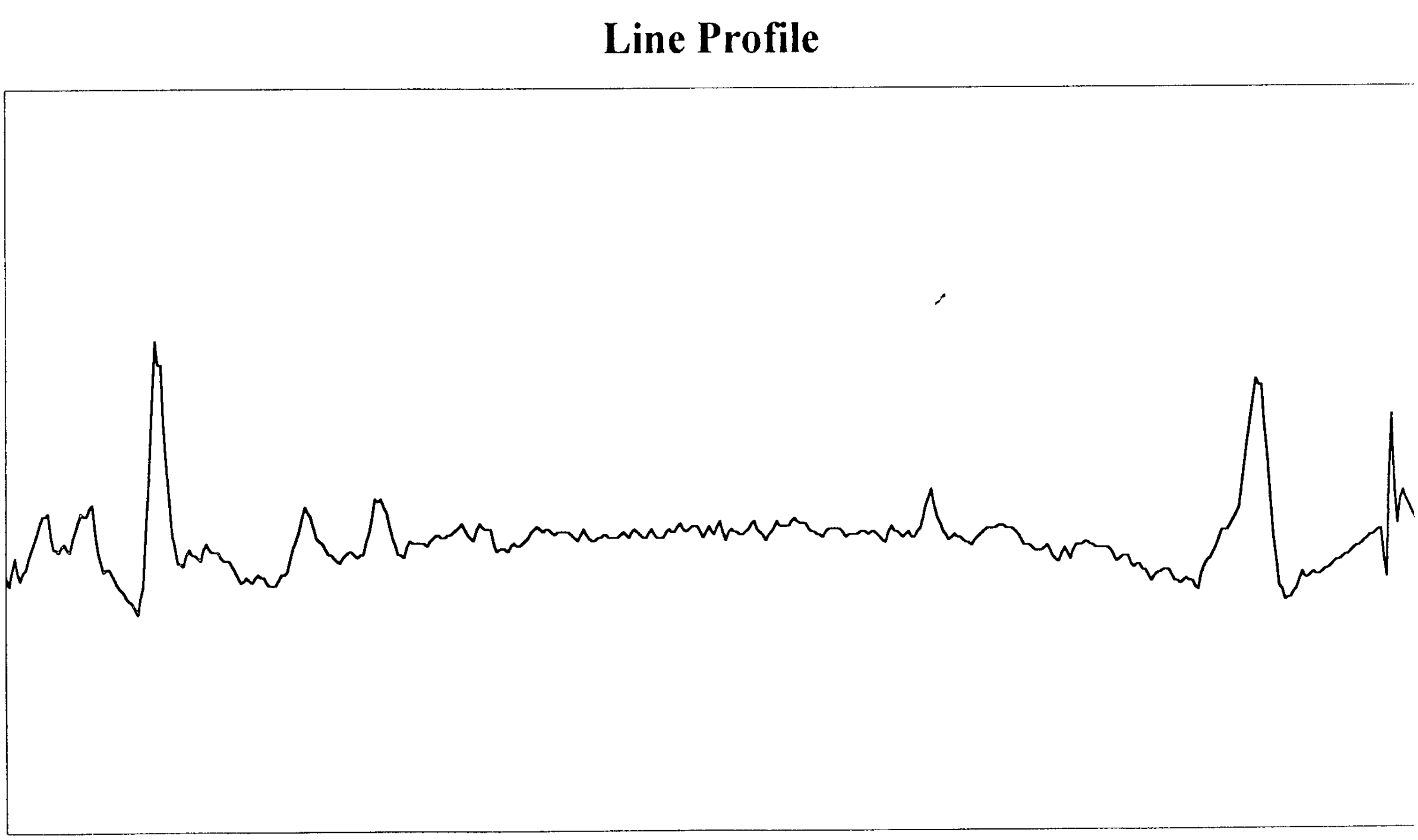
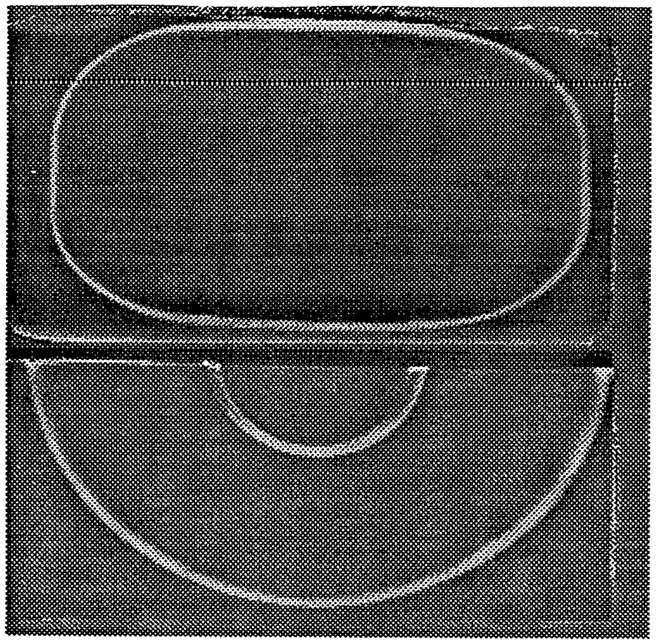


Figure 13a. Line Profiles of Grain0002 Image Corresponding to Figure 12a



Line Profile

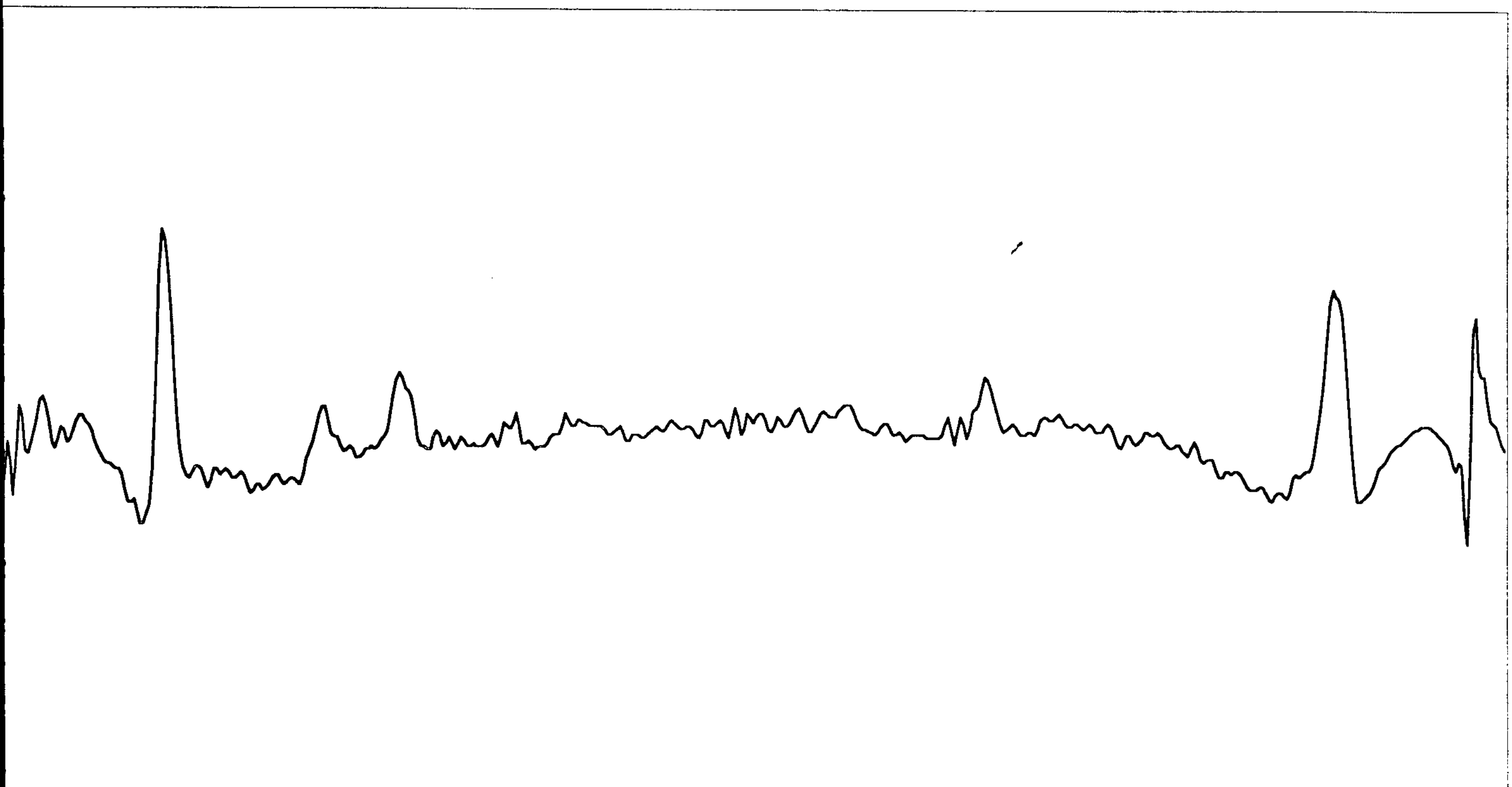


Figure 13b. Line Profiles of Grain0002 Image Corresponding to Figure 12b

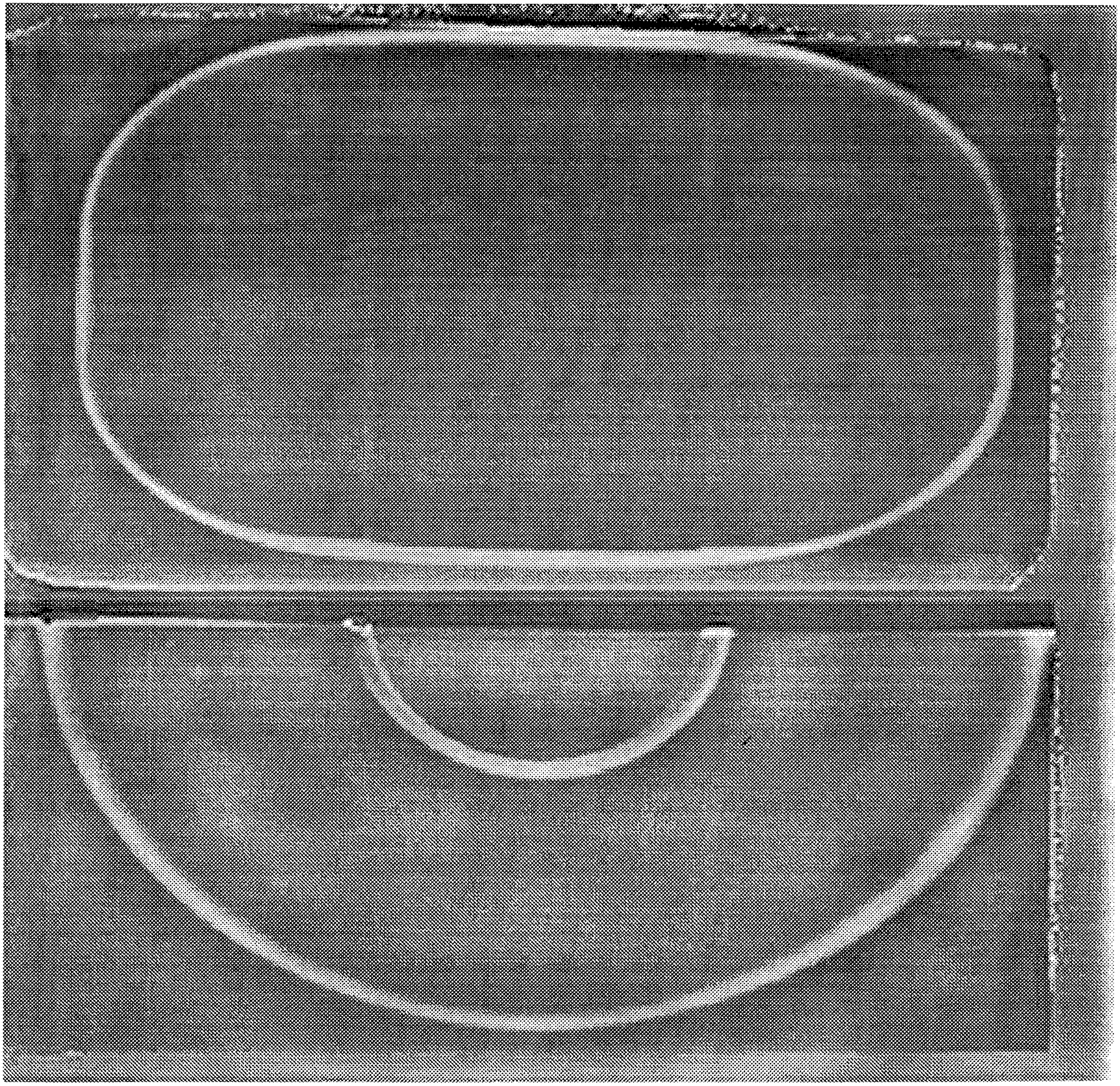


Figure 14a. Grain0002 Filtered by Mallat Battle Lemarie

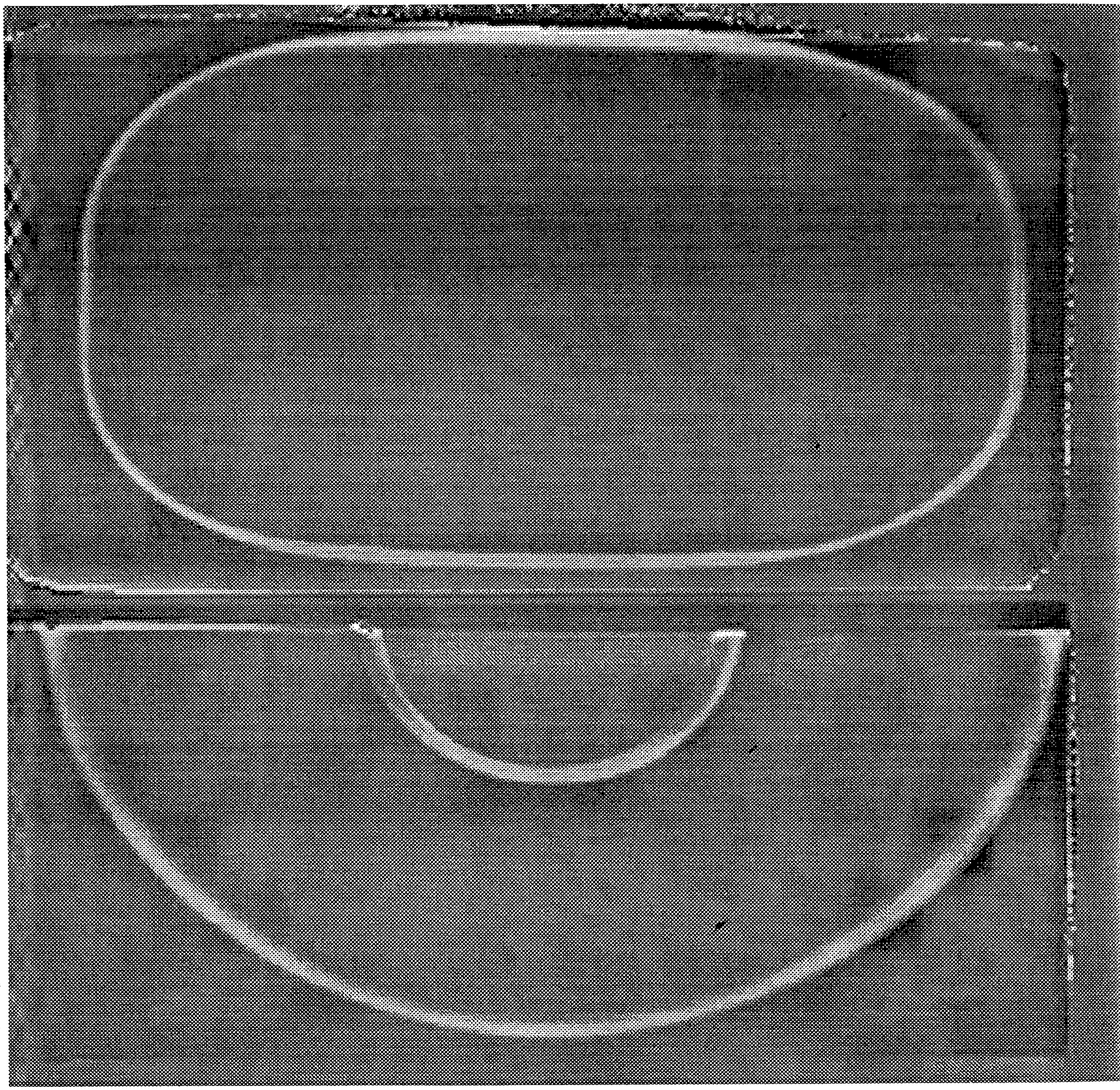


Figure 14b. Grain0002 Filtered by Spline3-7

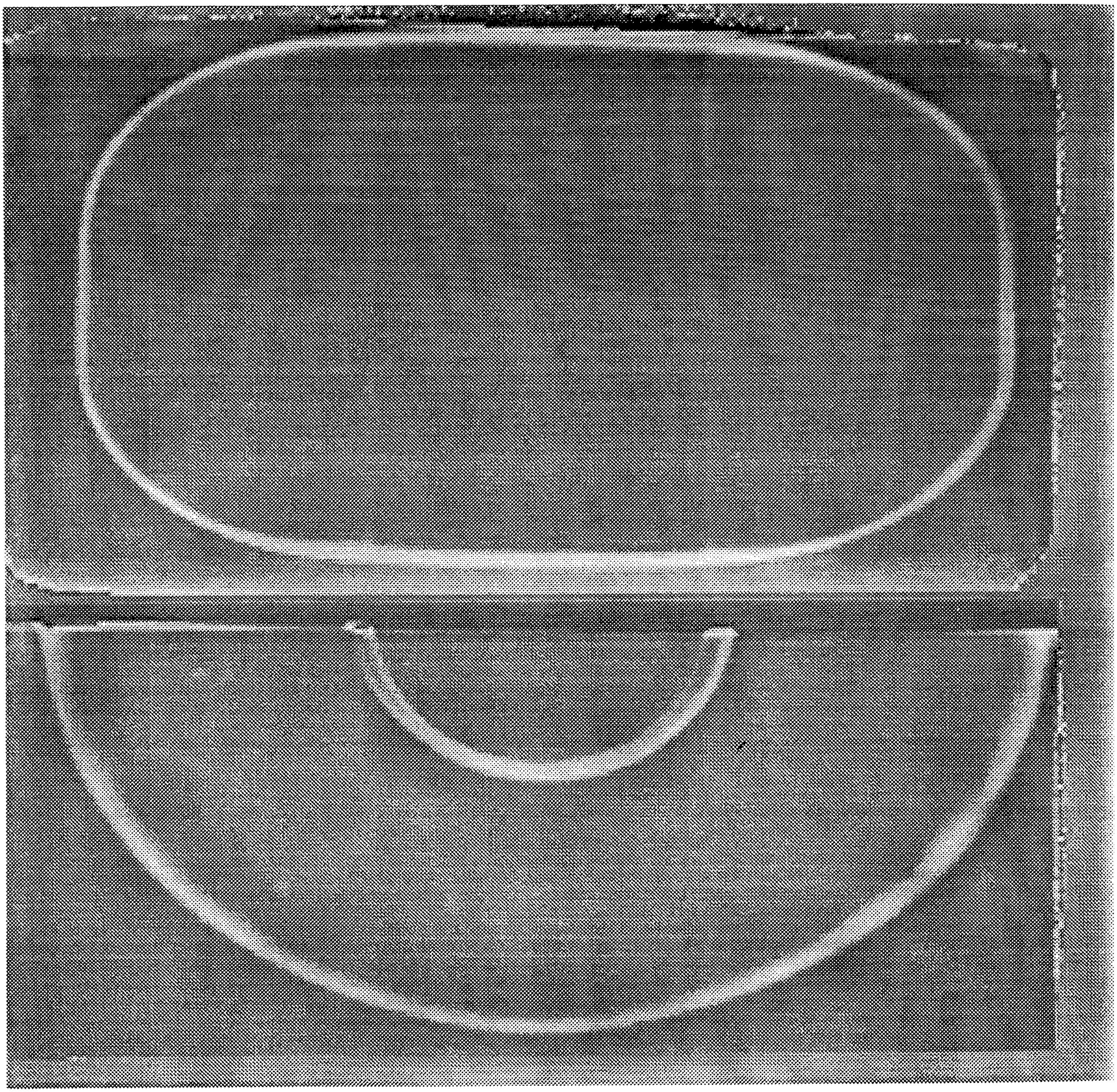


Figure 14c. Grain0002 Filtered by Spline2-2

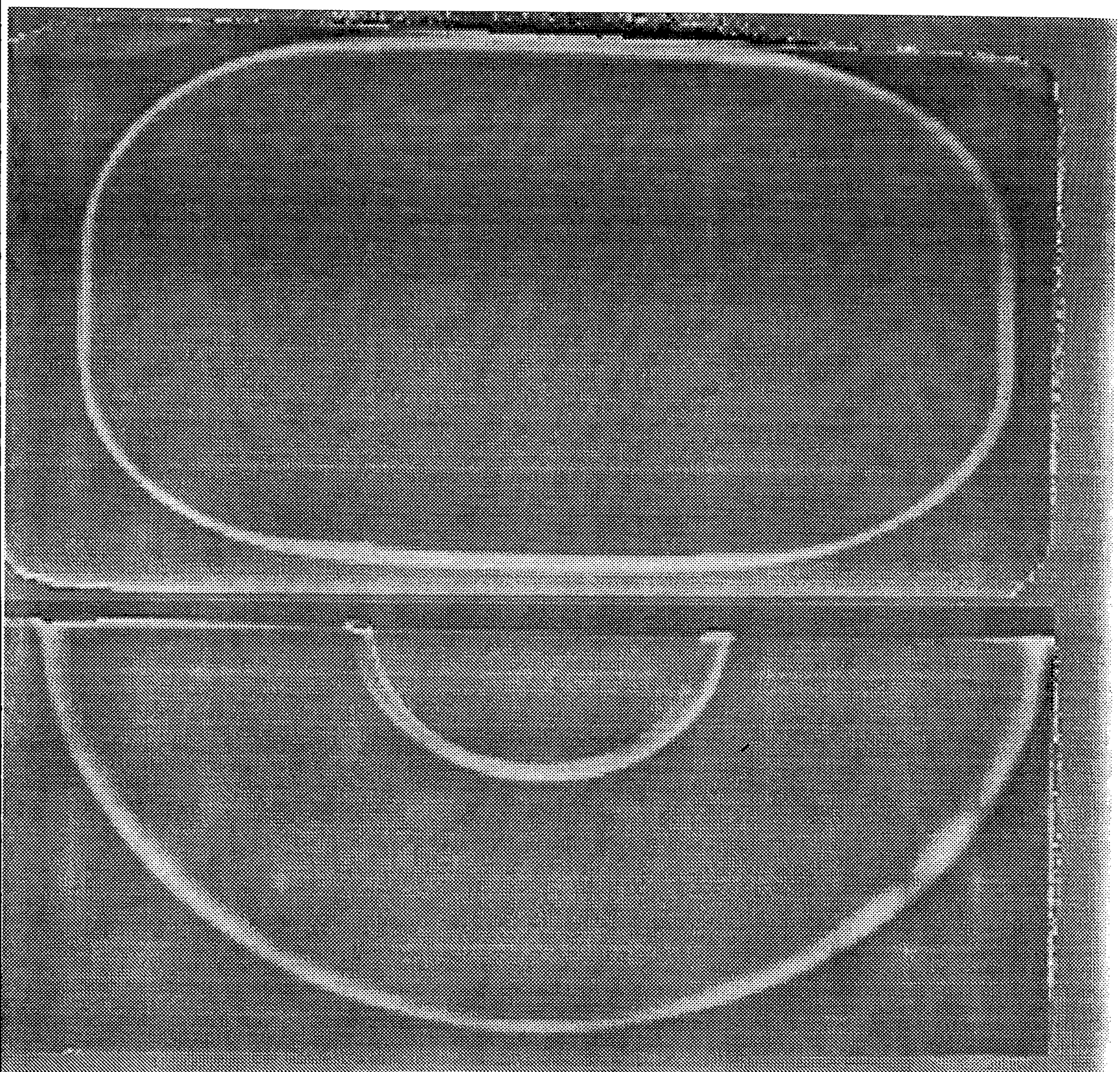


Figure 14d. Grain0002 Filtered by Burt Adelson

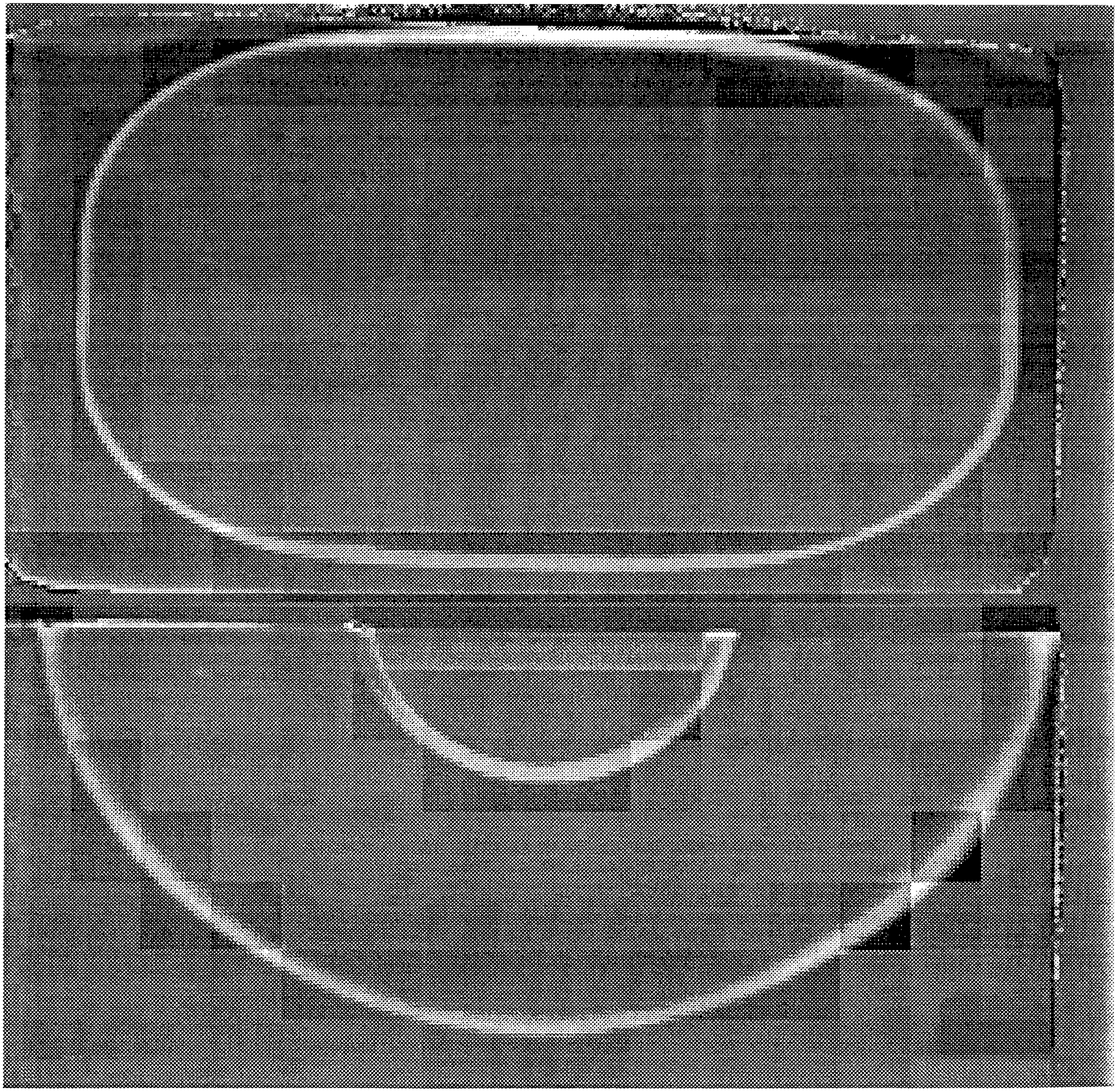
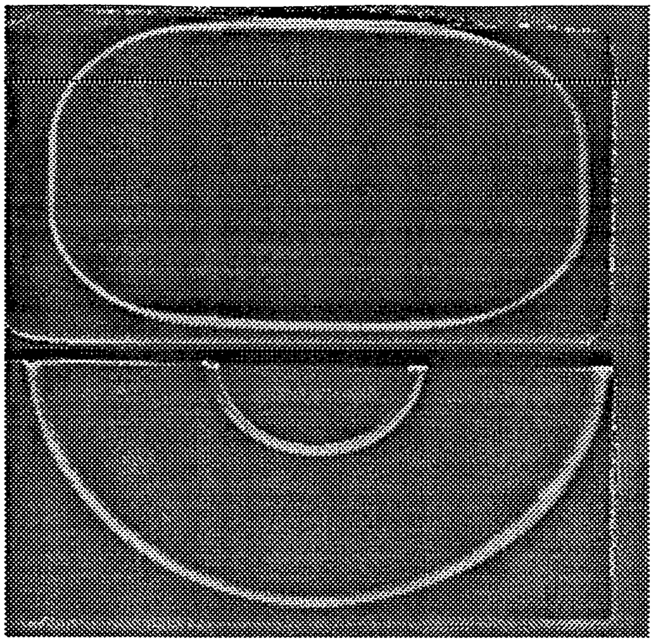


Figure 14e. Grain0002 Filtered by Haar



Line Profile

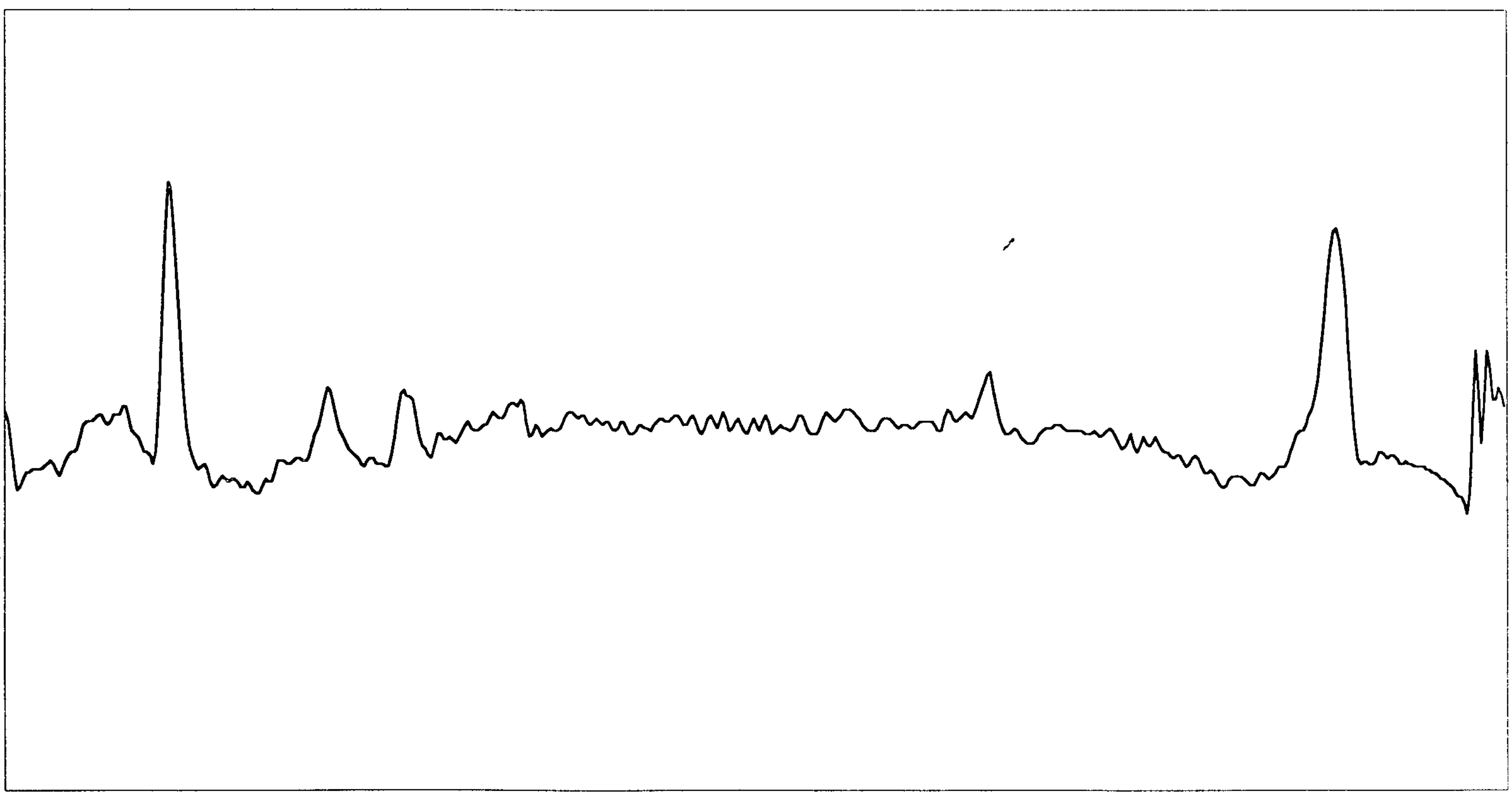
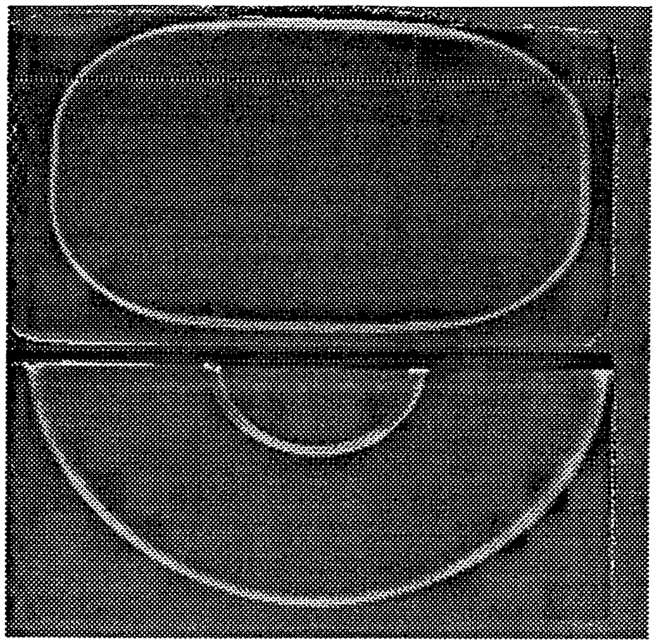


Figure 15a. Grain0002 Line Profiles Corresponding to Figure 14a.



Line Profile

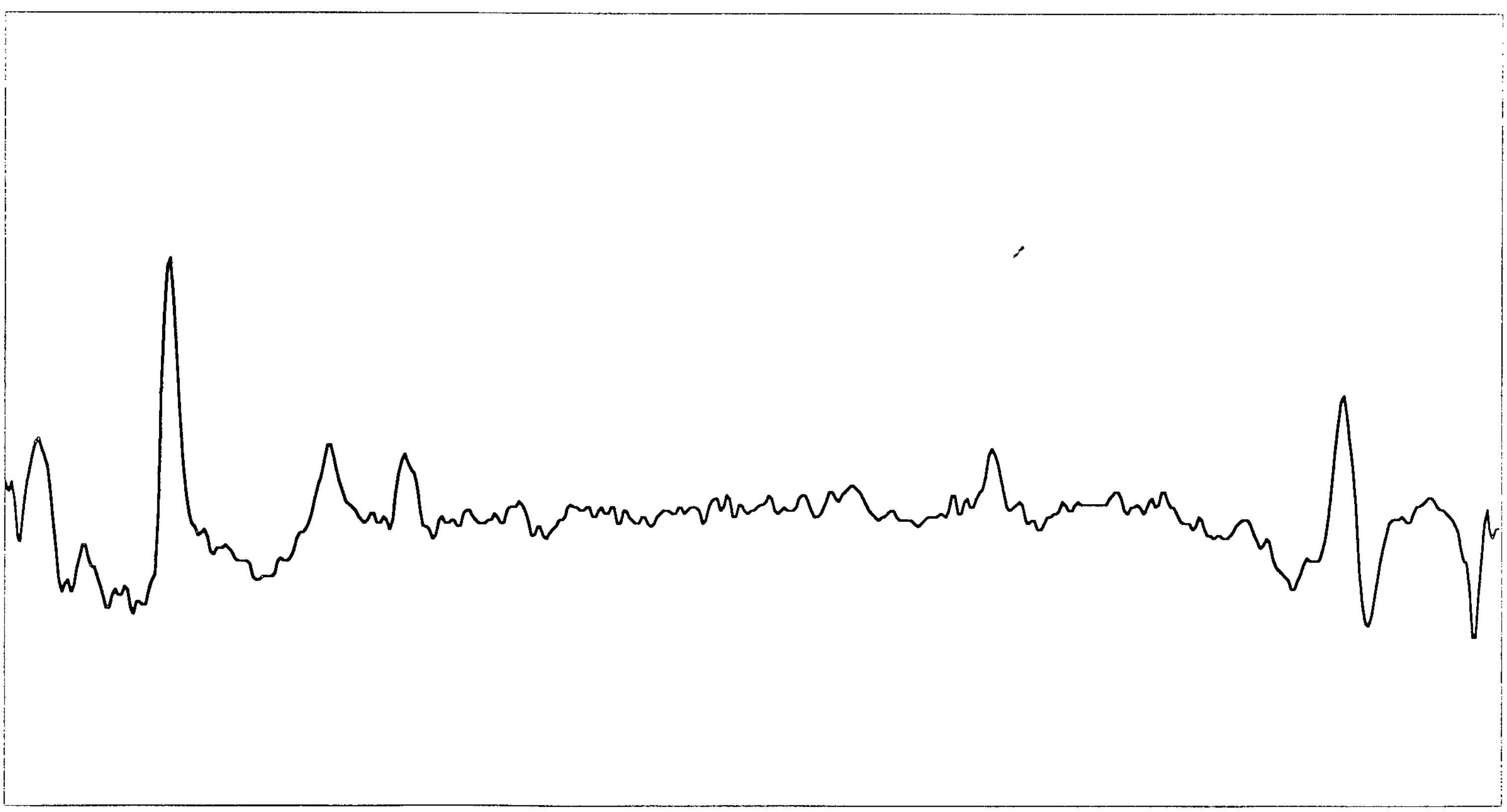
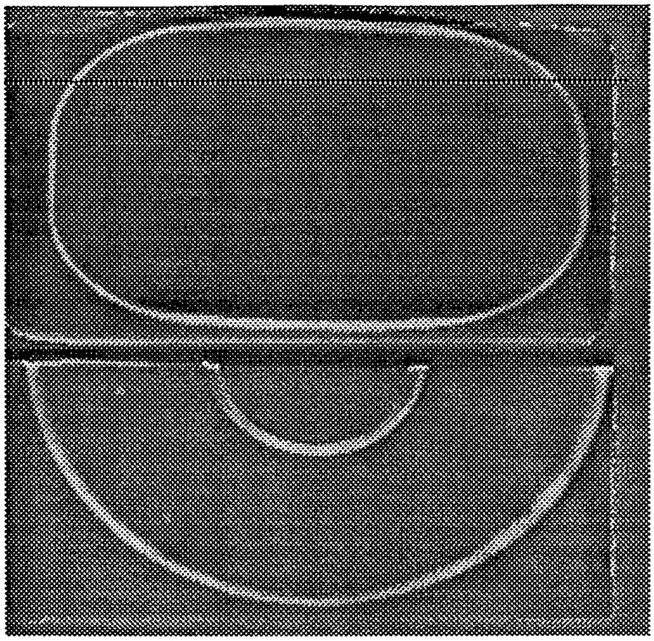


Figure 15b. Grain0002 Line Profiles Corresponding to Figure 14b.



Line Profile

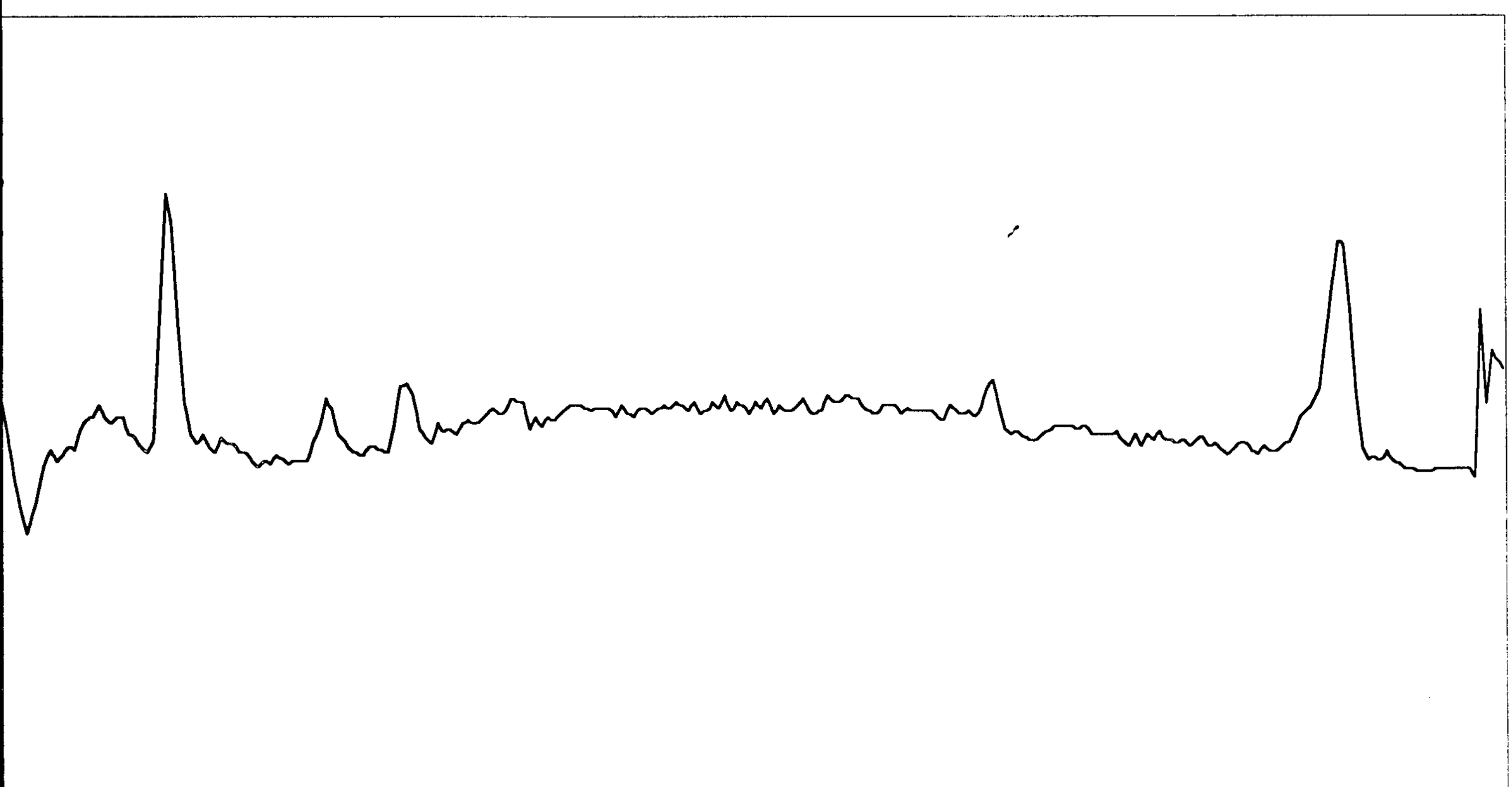
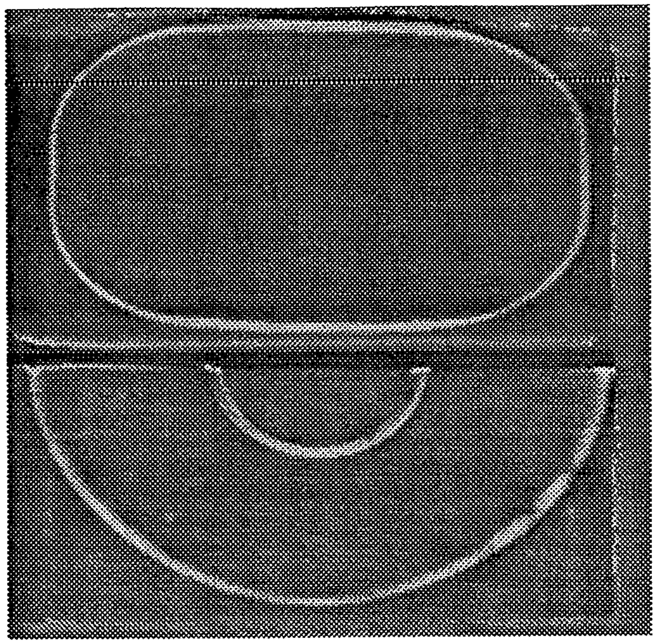


Figure 15c. Grain0002 Line Profiles Corresponding to Figure 14c.



Line Profile

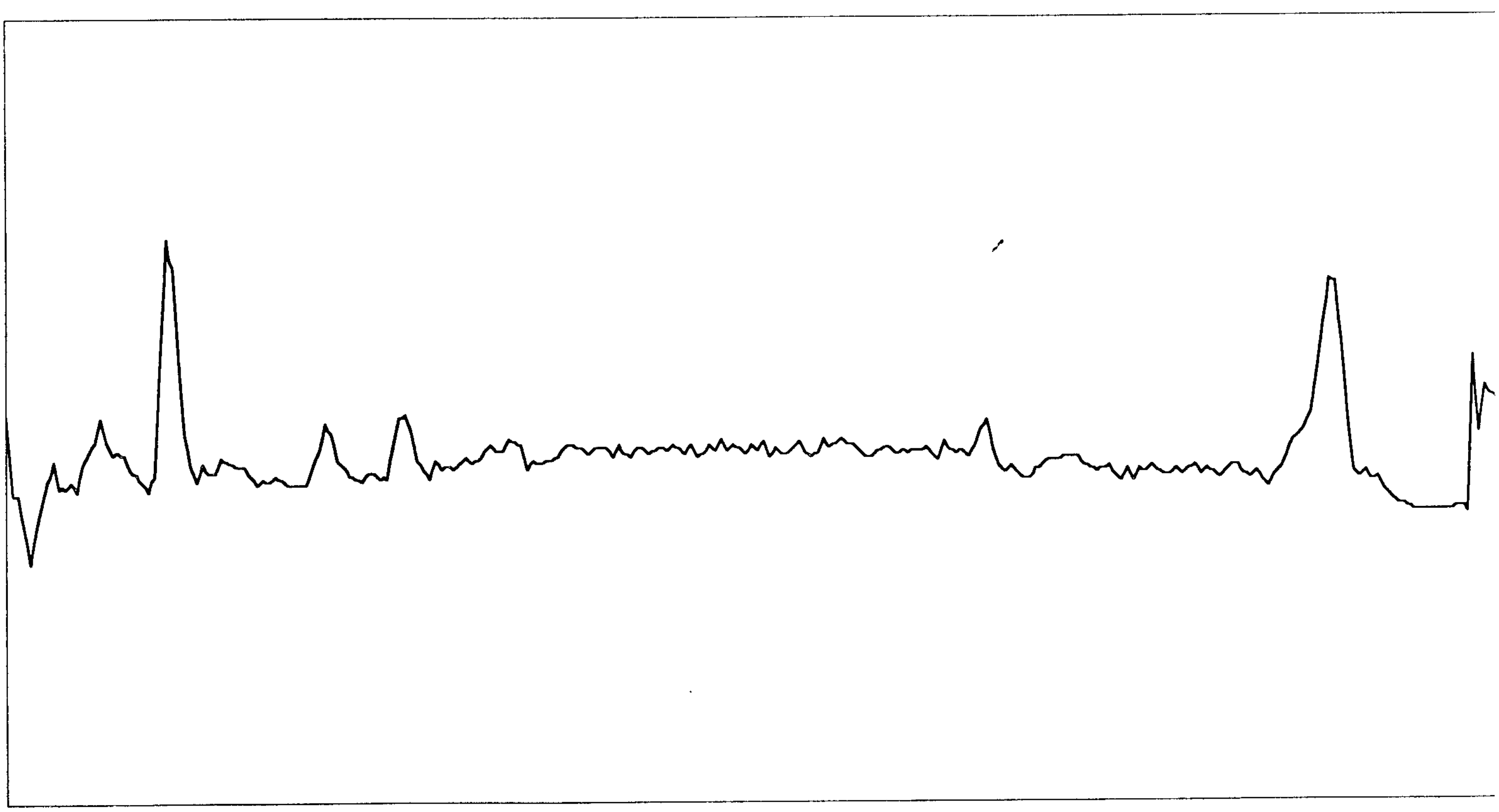
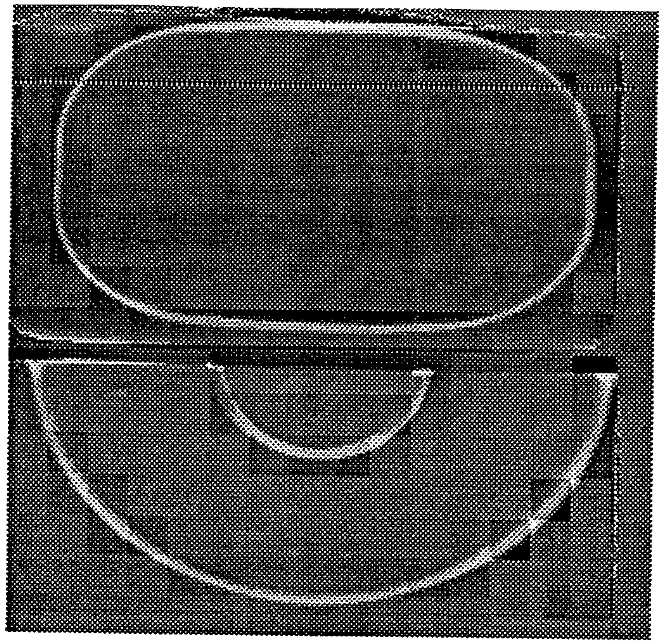


Figure 15d. Grain0002 Line Profiles Corresponding to Figure 14d.



Line Profile

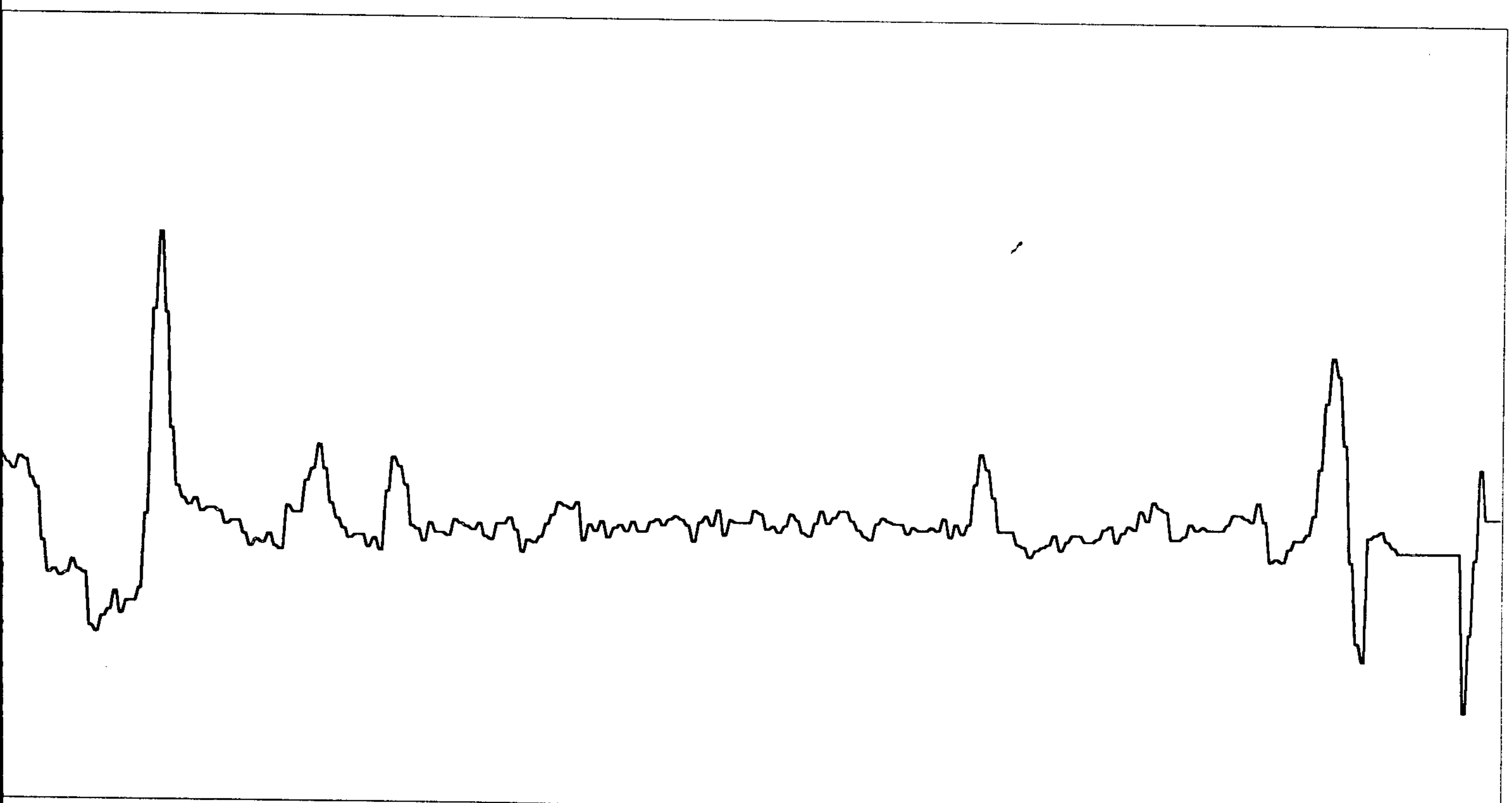


Figure 15e. Grain0002 Line Profiles Corresponding to Figure 14e.

but both introduced some of the blocky characteristics seen with the Haar wavelet. The Mallat wavelet revealed the defects, but the line profile shows, just to the right of the two defect "blips", a noticeable rise occurs which could become a problem for subsequent image processing steps.

In general, the wavelet transform is very effective for de-noising at mutiresolutions. The more taps the filter uses, the smoother the reconstructed images--the penalty being increased computation time as mentioned above. A comparison of computation time between wavelets was significant also; the Mallat Battle-Lemarie filter takes almost twice the computation time as does the Haar or Coifflet-2 filter. Wavelets with more taps suppressed some of the very small or faint defects in the grain images. In order to obtain the smallest defects, we kept the number of taps low. However, we also needed to maintain an overall image smoothness for subsequent processing steps. Ultimately, a balance was made and the Coifflet-2 filter selected.

II.3.1.2 Fractal Processing

Fractal analysis can be used to model a wide variety of irregular, non-Euclidean geometric objects. Fractal dimension is a unique number which characterizes a given fractal object. Clouds, trees, coastlines, feathers, etc. all can be analyzed for a fractal dimension. A "point" has a fractal dimension of zero and a "line segment" a fractal dimension of one. A 2-dimensional image can be understood as a set of points on a 2-D surface and the fractal dimension can range anywhere from 0 to 2. The fractal dimension is supposed to measure surface "roughness" or "complexity". The computation of the fractal dimension of a 2-D image has become an important issue in texture analysis. The fractal dimension can be computed from the expression:

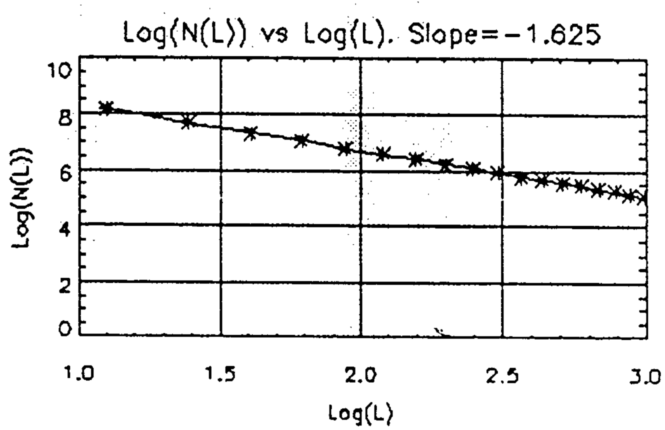
$$d = -\lim_{l \to 0} \frac{\log N(l)}{\log l}$$

where N(*l*) is the smallest number of boxes (of length *l* on a side) to cover the object. This box counting algorithm works for any cover shape that is measurable, such as a disk for example.

There have been several algorithms for estimating fractal dimension of an image, such as the box counting method, Fourier methods, wavelet based methods, morphological methods, etc. Initially we used the basic box-counting method for binary images. Some famous fractals were used for testing the program. For example, when applied to the Sierginski Gasket with a known dimension of 1.585; the box counting procedure, written using a commercial image processing package, IDL, gave a value of 1.63 as shown in Figure 16. Appendix D shows the box counting algorithm applied to some classical fractal images for which the dimension is known exactly. The procedure was used to analyze the fruit radiographs (orange, apple, banana, etc.) which were sharpened, edge detected, and binarized (a binary image created). The fractal dimension of the binarized image was calculated using the box counting method as shown in Figure 17 for a pear; the fractal dimension of the fruit images are shown in Appendix D. Those results were part of our February 20 presentation. Although the fractal dimension computation was not precise, the results suggested that the fractal dimension should be a useful feature for characterizing different objects such as fruits.

Dr. Raj Acharya, Professor of Electrical and Computer Engineering, SUNY at Buffalo, has published his work on "Analysis of Bone X-Rays Using Morphological Fractals" [ach93]. It

The Sierginski Gasket is a classic fractal with a known dimension of d=log(3)/log(2)=1.585. The dimension measured by box-counting is 1.63.



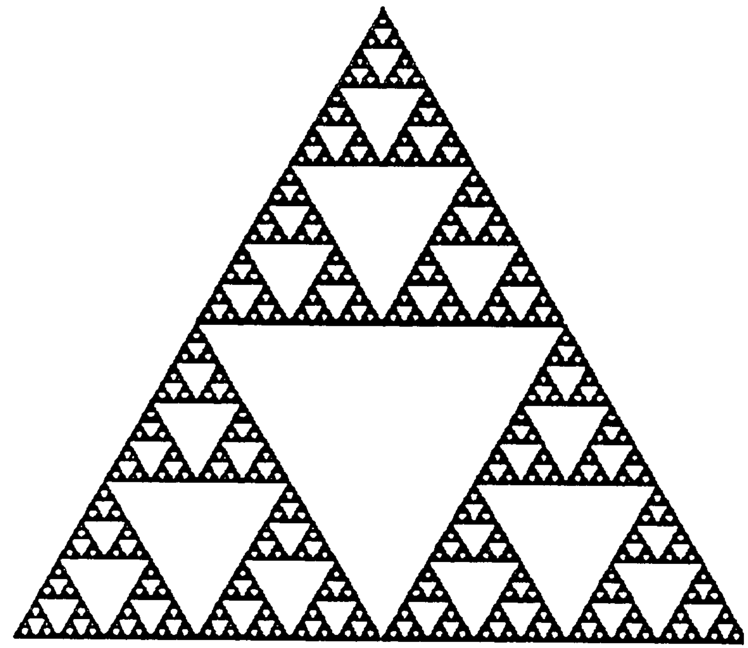
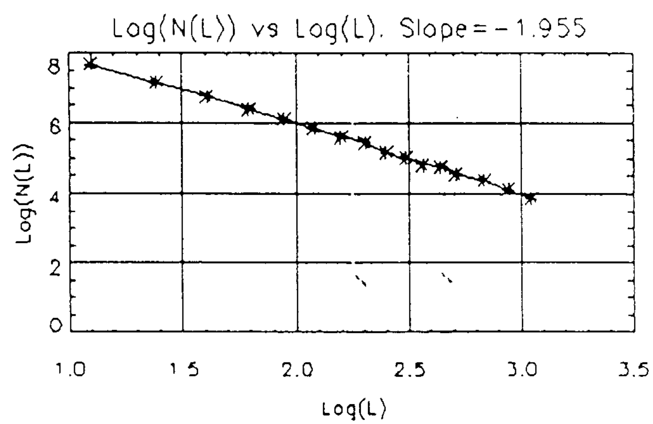


Figure 16. Sierginski Gasket using Box Counting Procedure

A section of the surface of a pear that has been enhanced by sharpening, edge detected, and binarization.. This surface has a fractal measure of approximately 1.96



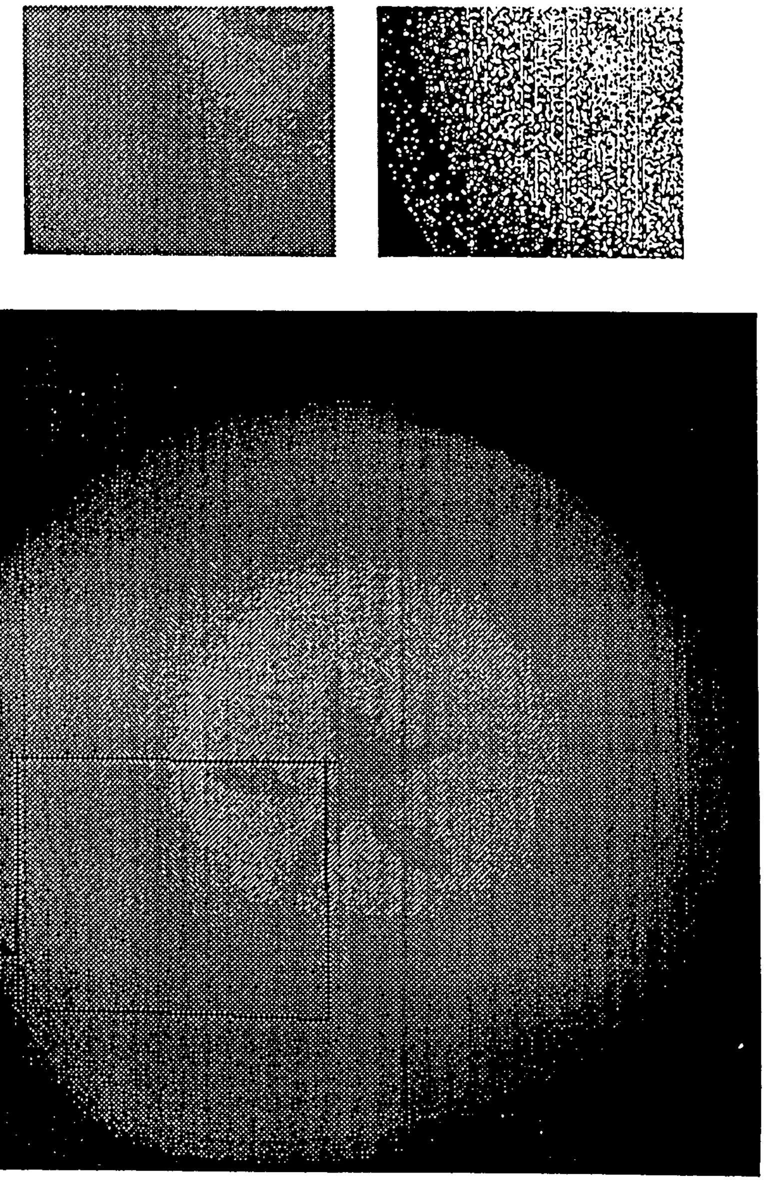


Figure 17. Fractal Dimension of Pear using Box Counting Procedure

is a new algorithm for estimating the fractal dimension of gray level images based on "mathematical morphology" and is believed to be more accurate than the traditional algorithms. Figure 18 summarizes the calculation flow of this algorithm. We have included this algorithm in our application for detecting defects in the grain images. The number calculated was used as one of the neural network features. Results showed that this number improved the neural network's ability to detect defects. Further investigation needs to be done on calculating the fraction dimensions of a limited region of an image such as might be found with various fruits or other agricultural products inside passenger luggage.

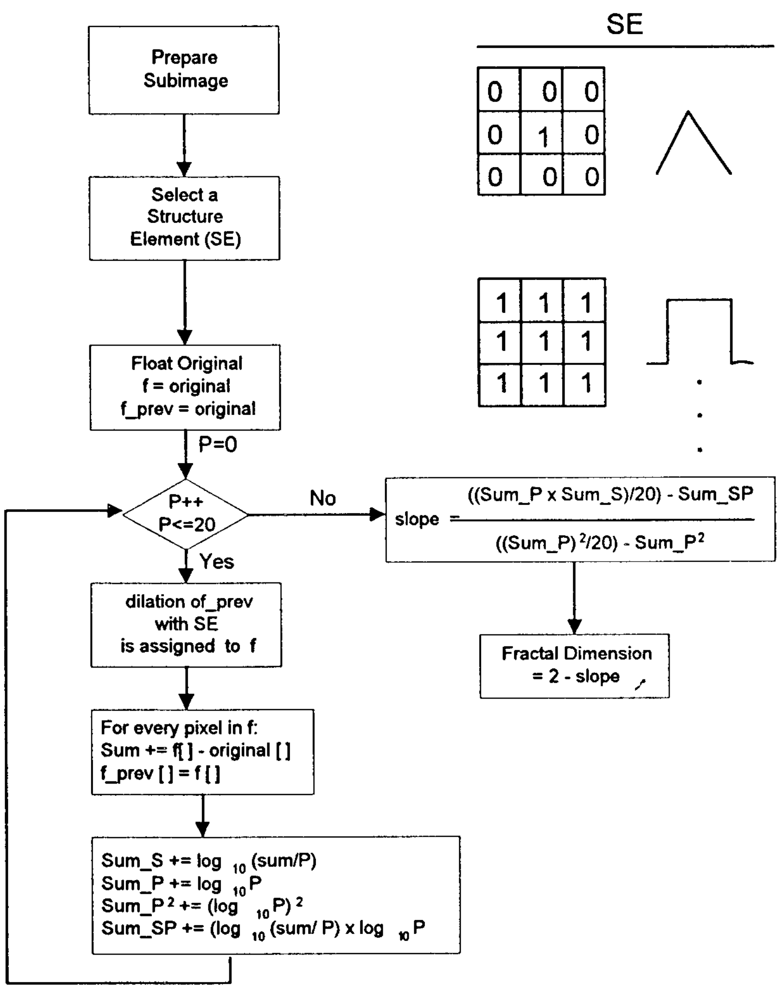


Figure 18. Acharya Algorithm Fractal Dimension

II.3.2 Image Processing Implementation

Figure 19 presents, side by side, the proposed image processing flowchart and the actual image processing and data analysis sequence that was implemented in a prototype that would be used in automatically identifying defects in the propellant castings. Note the specific sequence required for object isolation and that fractal dimensioning is incorporated within the "compute feature vector" step of the image processing.

Noticeably missing from the actual sequence shown is the use of histogram equalization; a technique used in the February 20th presentation. This technique is a transform that evenly distributes the original histogram of an image along the gray level range without changing its black-white order. The process increases the dynamic range of the gray levels and consequently produces an increase in image contrast thereby significantly improving the image's "visual" appearance.

The technique showed good results with the suitcase images. However, the objects (defects) in the grain image are small and faint. As the contrast of the whole image was increased by this technique, the defects became more deeply buried into the background noise. In other words, the background noise becomes the dominant part of the image and histogram equalization enhances more on noise than on the desired objects, so the technique was eliminated.

II.3.2.1 Image filtering

A considerable number of experimental filter sequences were attempted which led to the modified sequence shown in Figure 19. As the narrative describes the sequencing shown in Figure 19, the rationale for certain decisions should become clear.

II.3.2.1.1 Pre-Wavelet Processing

1. Remove Powder Signature

This procedure was used to common image features. Twenty (20) raw defect-free images were averaged on a pixel-by-pixel basis. For each pixel

$$p_{ua}(i,j) = p_{raw}(i,j) - p_{ave}(i,j)$$

The resultant image, referred to as the image under analysis, Iua, is the set:

$$\{p(i,j) | 0 \leq 1 < Xsuze,\ 0 \leq j < Ysize\}$$

where Xsize = 512; Ysize = 496

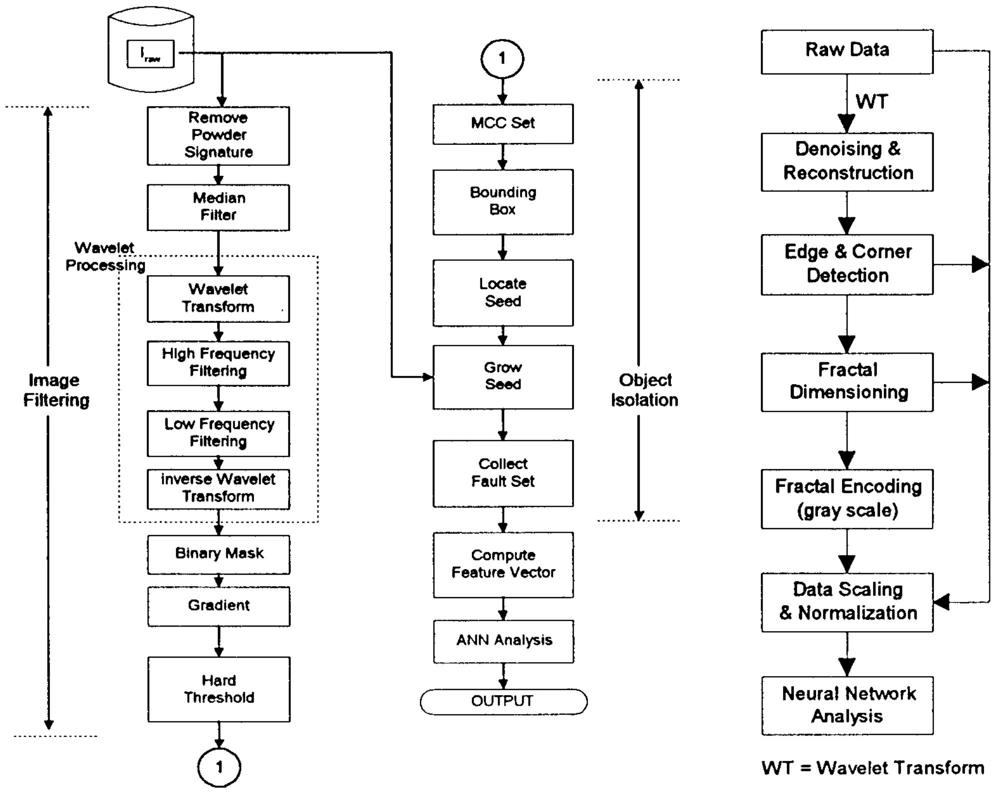


Figure 19. Image Processing: Actual Vs. Proposed

It should be noted that background noise, which by its very nature is random, is not suppressed--only features common to all images. Thus, the strong outline created by the plastic shell used to hold the propellant castings is significantly reduced.

2. Median Filter

Since the location of defects is critical, any noise reduction techniques which blur or distort the edges of any abnormalities could adversely affect defect detection. The median filtering technique is particularly effective when the noise pattern consists of strong, spike-like components--exhibited in x-ray background, and the characteristic to be preserved is edge sharpness.[rcg93] The gray level of each pixel is replaced by the median of the gray levels in a neighborhood of that pixel, instead of by the average, and is depicted in Figure 20.

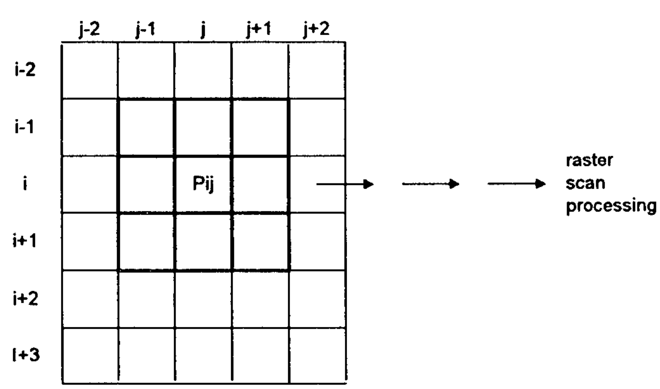


Figure 20. Median Filter

Our median filter used a 3x3 kernel. The resultant image is

$$p_{ij} = Median \left\{ p_{k\ell} \middle| i - m \le k \le i + m,\ j - m \le \ell \le i + m \right\}$$

where m = 1 for 3x3; m = 2 for 5x5, etc.

II.3.2.1.2 Wavelet Processing

AnSim's filter involved the use of the Coifflet-2 wavelet with a 5-level decomposition. The selected frequency components removed were the three highest frequency sets of coefficients from the 1st level decomposition and the set associated with the lowest frequencies found in the 5th level of decomposition as shown by the shaded areas in Figure 5.

The impact of these first three steps is evident if one takes a cross-sectional slice of the 2-D image and plots pixel gray-level value vs. pixel position. Figure 21 shows a typical raw image with the white horizontal line indicating from where the cross section has been chosen (See Figures 8a and 9a). The line has been superimposed on two defects.

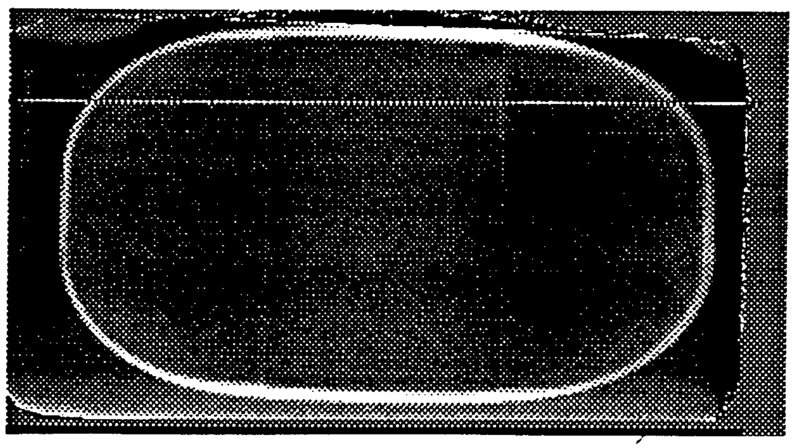


Figure 21. Sample Raw Image

The Figure 22(a-e) sequence shows the results of removal of consistent characteristics, median filtering and wavelet processing. Figure 22a shows the raw image before any processing; note the two large spikes near the ends of the plots indicative of the bright lines representing the plastic container used to hold the casting while the image is taken. Figure 22b shows the results of averaging twenty images; again the plastic container is very evident as is a rather low frequency component in the center of the image. Figure 22c shows the subtraction of the average from the raw; the plastic container has been dramatically reduced as has the low frequency component in the center; as expected, high frequency noise remains. Figure 22d shows the noise reduction as a result of median filtering; the two closely spaced peaks to the left side of the plot are two closely spaced defects. Figure 22e shows the results after applying the wavelet filtering procedure described above, followed by image reconstruction.

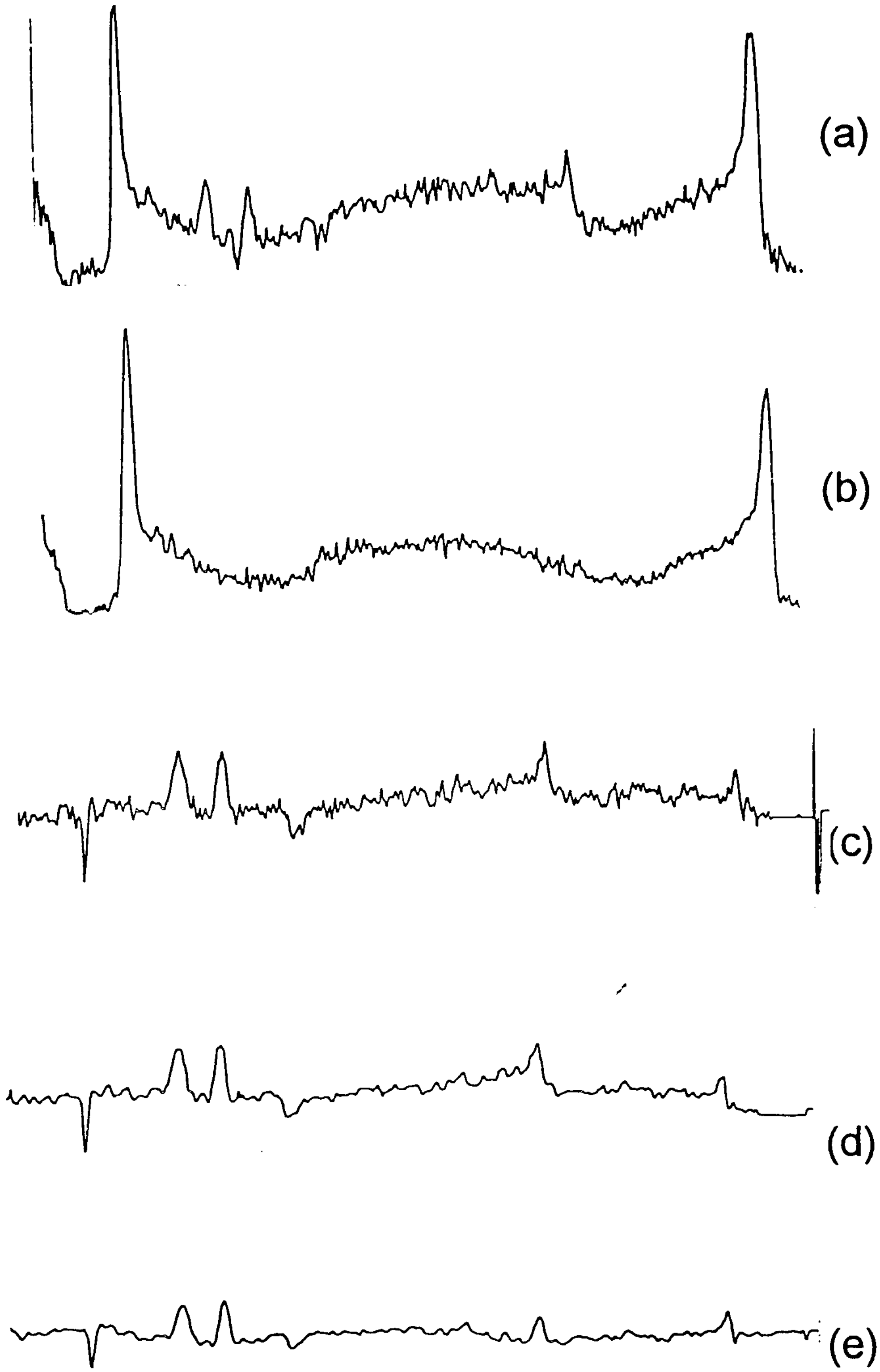


Figure 22. Filter Effects on Grain0002 as Viewed by Line Profile: (a) original; (b) average of 20 defect-free images; (c) digital subtraction of b from a; (d) median filtering and (e) wavelet filtering

II.3.2.1.3 Post-Wavelet Processing

1. **Binary Mask**

Subsequent processing steps can be quite computationally intensive. To minimize effort, a binary mask was created to "fit" over the orientations of the casting images. The mask substituted null values in the region outside the casting image. In the last few days of methodology refinement, a procedure was perfected to automatically develop the mask (Figure 23).

1. **Trim the picture edge**
2. **Compute the threshold value V_o which is the maximum V such that**
   $$\sum_{i=0}^{V} N(255-i) > \frac{1}{10} N_{total}$$
   where N(k) is the number of pixels with gray value of k
3. **Threshold the original (or denoised) image to get a binary mask**

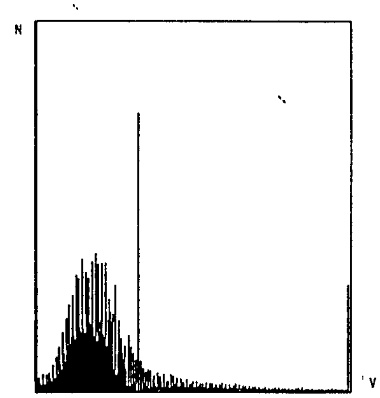
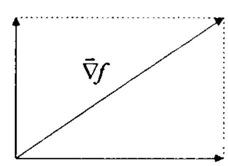


Figure 23. Dynamic Mask Procedure

2. **Gradient**

The pixels representing the boundary layer between the uniformly molded casting and a defect showed a noticeable change in gray-level values. The mathematical derivative function (i.e., slope) of the plot shown in Figure 21e would show a strong change in the region of each of the defect "peaks." For 2-D images, the gradient of a function f(x,y) at coordinates (x,y) is defined as the vector:

$$\bar{\nabla} f = \begin{bmatrix} \dfrac{\partial f}{\partial x} \\ \dfrac{\partial f}{\partial y} \end{bmatrix}$$



The magnitude of the vector is: $\nabla f = mag\left(\bar{\nabla} f\right) = \left[\left(\dfrac{\partial f}{\partial x}\right)^2 + \left(\dfrac{\partial f}{\partial y}\right)^2\right]^{1/2}$

It can be shown that for a 3x3 cross-gradient operator:

Z_1	Z_2	Z_3
Z_4	Z_5	Z_6
Z_7	Z_8	Z_9

where Z_i is the pixel gray-level value, that a number of operator masks can be used.

We used the Sobel operators:

-1	-2	-1
0	0	0
1	2	1

and

-1	0	1
-2	0	2
-1	0	1

$$\nabla f \approx \left|(Z_7 + 2Z_8 + Z_9) - (Z_1 + 2Z_2 + Z_3)\right| + \left|(Z_3 + 2Z_6 + Z_9) - (Z_1 + 2Z_4 + Z_7)\right|$$

The effect of the gradient operation was the creation of hot spots; narrow areas where the derivative changed rapidly leaving higher (orlower) intensity pixels as compared to the surrounding area associated with a rapid positive (or negative) slope change.

3. Hard Thresholding

Applying a hard threshold to the gradient-processed image creates a binary image. Given some threshold value:

- pixels $\geq$ threshold set to 255
- pixels < threshold set to 0

The threshold parameter is one which may be varied resulting in reduced false alarms at the risk of missing defects or increased defect detection with concomitant increase in false alarms.

II.3.2.2 Object Isolation

1. MCC Set

The binary image obtained above is processed to find the Maximum Connected Component (MCC) set. Figure 24 shows a map fragment, the processing directions and several example MCCs. Each MCC, C_i, is determined and included in a set:

$$S = \bigcup_{i=1}^{N} C_i$$

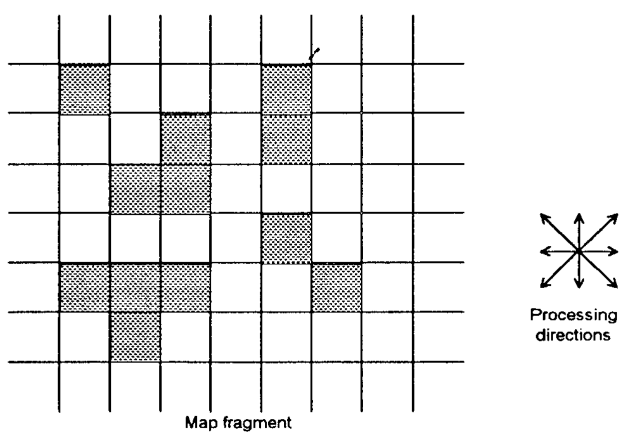


Figure 24. Map Fragment

where C_i = the i^{th} MCC. The set, S, is maintained as a list of entries. For each MCC, C_i, the maximum and minimum x and y coordinates are found. Then C_i is enclosed in a box defined by two normals to the y axis at the y

max and min, and two normals to the x axis at the x max and min (Figure 25). In some cases the four normals may collapse to two as is the case for a straight vertical or horizontal line.

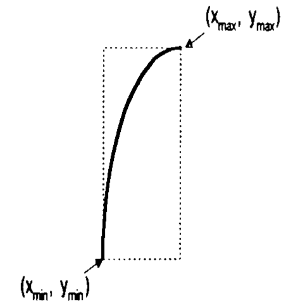


Figure 25. MCC Set

2. Locate Seed

A shell superimposed a second rectangular box to fit outside the MCC box described in the previous step. Using the coordinates of the MCC box and the shell, the pixels of the I_{ua} are analyzed as follows:

- The pixel average is computed inside the shell
- The pixel average is computed inside the MCC box
- A growing seed is located inside the MCC box, the coordinates of which are
  - * that of the lightest pixel if the shell average is darker than the MCC average
  - * that of the darkest pixel if the shell average is lighter than the MCC average

The seed location is shown in Figure 26.

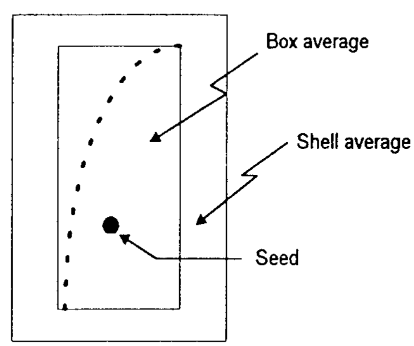


Figure 26. Locate Seed

3. Grow Seed

The seed growth algorithm is shown in Figure 27. A gray-level average is computed for a 3x3 kernel surrounding the seed:

$$p_{ave} = \frac{1}{9} \sum_{k=i-1}^{i+1} \sum_{\ell=j-1}^{j+1} p_{ij}$$

The seed is allowed to grow into the region where the pixel values meet the following requirement:

$$|p_i - p_{ave}| \leq \Delta P$$

where ΔP is an arbitrary parameter. For the Phase I analysis, a value of 10 was used for ΔP

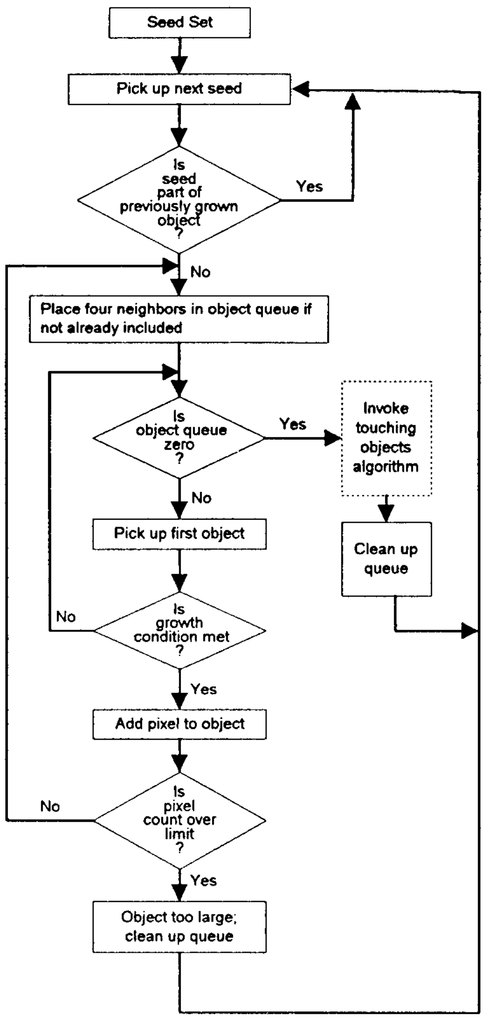


Figure 27. Seed Growth Algorithm

and is referred to as the growth condition In general, the larger ΔP, the larger will be the region into which the seed will grow. We expect to achieve better results in Phase II with an adaptive seed-growing algorithm. One such example is to inspect the pixel intensities at the perimeter of the seed as it grows and adapt the changes to more accurately locate the boundary of the anomaly. Note the algorithm rejects a defect that becomes too large which can happen if a stray seed grows outside of an object. A major refinement needed is the development of the algorithm to determine when objects are touching one another. This significant effort, shown as a "dotted" process in Figure 27, is scheduled for the DAXIS Phase II project. An example of how seed growth should occur is shown in Figure 28.

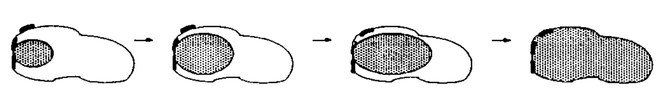


Figure 28. Grow Seed

4. Collect Fault Set

After seed growth, the C_i are collected into a set of growth regions as depicted in Figure 29

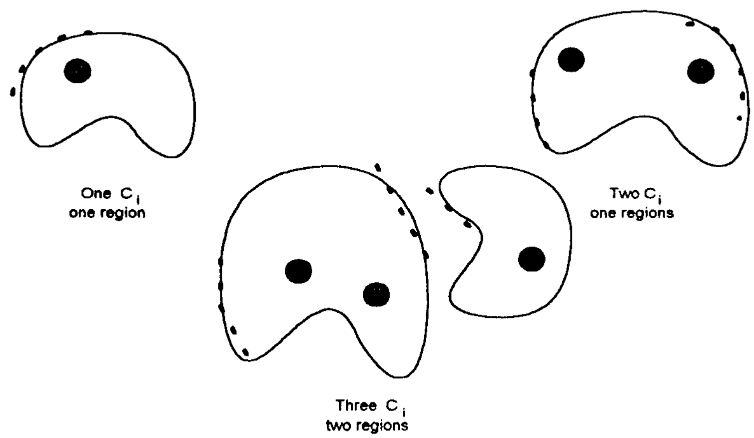


Figure 29. Collect Fault Set

II.3.3 Compute Feature Vector

The feature vector is created by processing the anomalies in the I_{ua} to obtain a set of quantifiable characteristics:

- location
- shape features (2)
- area features (2)
- mean ratio
- variance
- fractal dimension

1. Location

The anomaly coordinate centers are determined from the "bounding box" (Figure 30) and then normalized as:

$$x_{norm} = x_k \div x_{size}$$

$$y_{norm} = y_k \div y_{size}$$

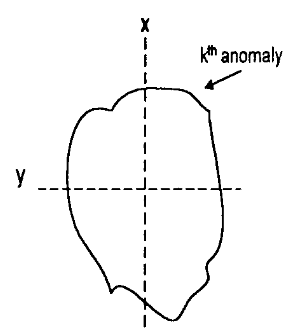


Figure 30. Location

2. Shape

a. Bounding Box Ratio

In a procedure similar to that described with the determination of an MCC, a "bounding box" is computed for each anomaly (Figure 31).

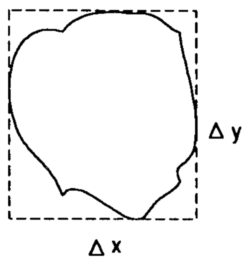


Figure 31. Bounding Box

The bounding box ratio, bbr is computed as the ratio of height to width:

$$bbr = \Delta y \div \Delta x$$

b. Isoparametric Inequality

This inequality is $P^2 - 4\pi A$ [dec76] where $P = 2\pi r$ the circumference of a circle enclosing the object and A is the area enclosed by the object of interest. If the object is a circle, $P^2 - 4\pi A = 0$ For our analysis, we compute

$\frac{P^2}{4\pi(A - P)}$ where A is the area in pixel count and P is the number of pixels in the perimeter. The computation is, within reason, independent of the size of the anomaly.

3. Area

a. Area, A, expressed as the total number of pixels inside the region of interest.
b. Area ratio: $A \div A_{bb}$ where A_{bb} is the area of the bounding box

4. Mean Ratio

The mean ratio is:

$$\text{anomaly\_mean} \div \text{regional\_mean}$$

where the regional mean is the mean of a shell surrounding the object as shown in Figure 32.

This computation will need refining. Presently, it is in jeopardy of capturing other anomaly fragments in the regional_mean calculation where there is the possibility of anomaly clustering.

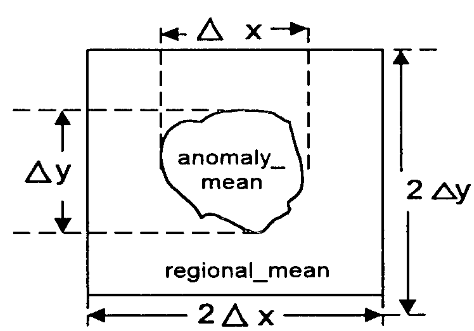


Figure 32. Mean Ratio

5. Variance

The variance of pixel values in the anomaly is computed.

6. Fractal Dimension

The fractal dimension computation as described by Acharya [ach93] and summarized in Figure 18.

II.3.4 Artificial Neural Network

The final step in the automation of object detection, identification and classification is the application of an Artificial Neural Network (ANN) as a nonalgorithmic approach to information processing, capable of processing large amounts of data simultaneously by "learning" from examples that are presented to the network repeatedly. For this effort we have utilized "NETS" (Version 3.0)* to provide a flexible system for manipulating a variety of neural network configurations using the Generalized Delta Back Propagation learning method.

This method starts out with the problem being expressed in a format which has input/output pairs. Such problems can be thought of as mapping or stimulus /response problems. Once the input and output pairs have been decided upon, a network configuration can be specified which will attempt to realize (through NETS) the desired mapping of inputs to outputs. Then the process of training the network begins. In NETS, this amounts to specifying the extent to which errors in the mapping process will be tolerated.

The basic building blocks of NETS (or any ANN) are the node and its connections. The node uses incoming connection values to calculate its output via a thresholding scheme. Connections have associated weights which modify the signal propagating down the connection. The network achieves its learning through changing these weight values. Teaching occurs when a set of data is presented which will cause the weighted values of the network to change in response to the input.

Typically, the nodes are grouped into clumps called layers. Networks have an input layer and an output layer tied to some features of the problem being solved. Intermediate stops between the input and output serve to help perform the desired mapping between an input and its corresponding output and are called hidden layers. Typical of networks which use the back propagation algorithm is the fully connected network, whereby all nodes in one layer are connected to all nodes in the adjacent layer as represented in Figure 33. This network configuration was utilized for this implementation.

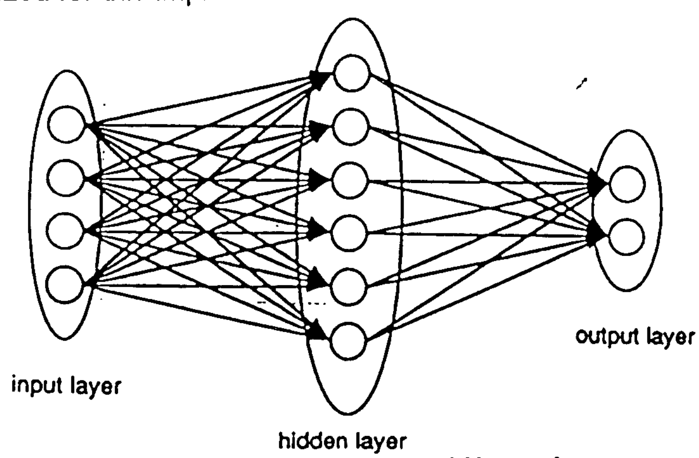


Figure 33. Fully Connected Network Configuration

* Developed by the Artificial Intelligence Branch (now SoftwareTechnology Branch) of NASA's Johnson Space Center.

III. PROTOTYPE CLASSIFIER SYSTEM -- DEMONSTRATION

The fourth objective of the Phase I effort was to demonstrate the Phase I prototype in order to assess the feasibility and ultimate system potential by analyzing "unknown" radiographs supplied by the Army. This objective was accomplished using a set of 1479 images of doughnut-shaped (cut-in-half) molded chemical propellant rocket motor castings ("Propellant Castings") provided by the Army COTR. For purposes of testing the system, the images were grouped in six (6) sets of about 250 images each. Three (3) sets would be used to train the ANN and three (3) to test it.

III.1 PROCESSING OF X-RAY IMAGES

The first step in preparing the inputs for both the training and testing of the system was the identification of defects to be found in each x-ray image, that is establish the ground truth for evaluating system performance. A limited Delphi approach was used to accomplish this task. In a Delphi approach, experts in the field (about 6) would individually score each image and then meet to discuss the results and develop a consensus. In our limited approach, an "expert" scored the images and the results were reviewed by a second "expert" and then discussed until a consensus was reached. Having access to both side and top views of the items, allowed for correlation of the results.

Figures 34, 35, and 36 show images #103, #104, and #105, respectively, and the types of defects identified (#103 → 1, #104 → 2, #105 → 4).

The second step involved the processing of the image using the processing sequence presented in Figure 19 of Section II.3.2 in order to isolate objects (anomalies) in each image by set, and to calculate features vectors for each anomaly (suspected defect). Table 1 summarizes definitions of the nine (9) components of the features vector and the nomenclature for each. Table 2 presents sample processing outputs for Images #93 through #110. Note that no anomalies were detected in images #94, #97, #99, #100, #102, #108, AND #109. Also, remember that according to the ground truth data only images #103, #104, and #105 from this sample group had defects.

TABLE 1. FEATURES VECTORS SUMMARY

Nomenclature	Definition
centerx & centery	x, y -- coordinates (pixel) at center of anomaly
area/500	Area (no. of pixels) of anomaly
hsz/vsz	Ratio of horizontal (H) to vertical (V) dimension of anomaly
area/box	Ratio of area of anomaly to area of bounding box A ÷ (HxV)
lmn/gmn	Ratio of local mean to regional mean
lvr/256	Variance within anomaly
per*per-4pi*area	Isoparametric inequality -- P2/4Π-(A - P) where P = 2ΠR circle enclosing anomaly A ~ area
fr_dim	Fractal dimension of anomaly

Figure 34

IDENTIFICATION OF DEFECTS

Image #103

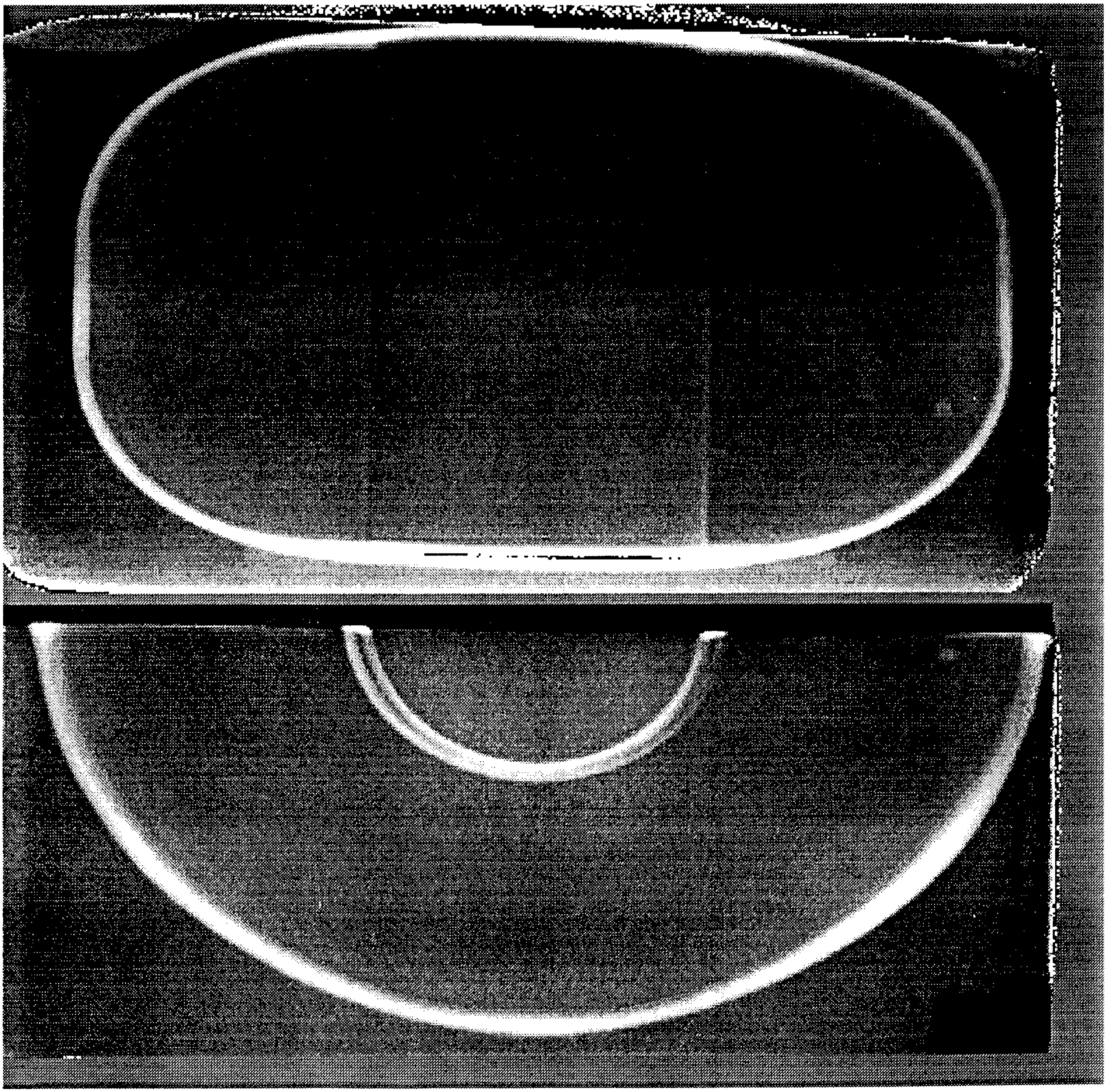


Figure 35

IDENTIFICATION OF DEFECTS

Image #104

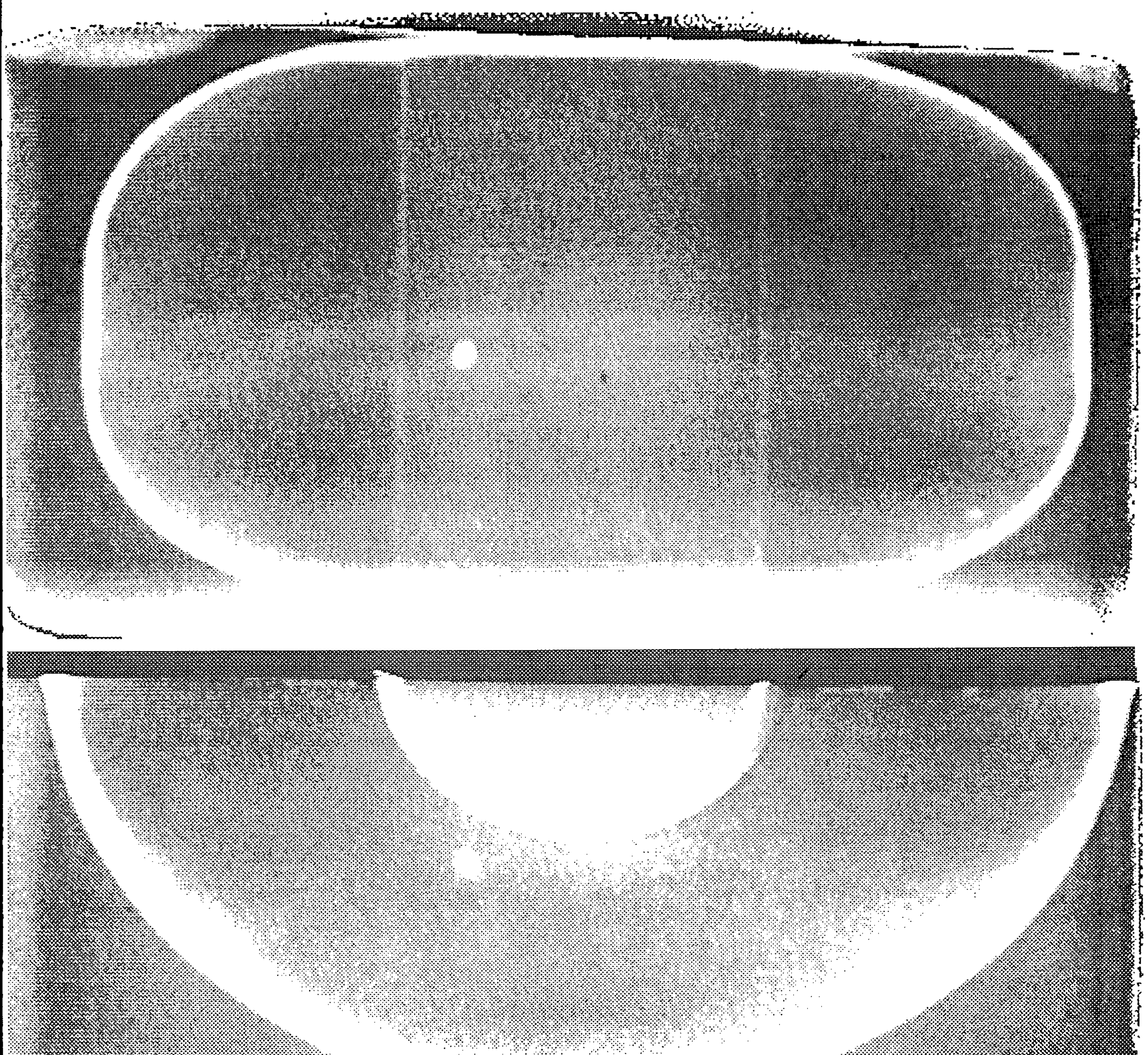


Figure 36

IDENTIFICATION OF DEFECTS

Image #105

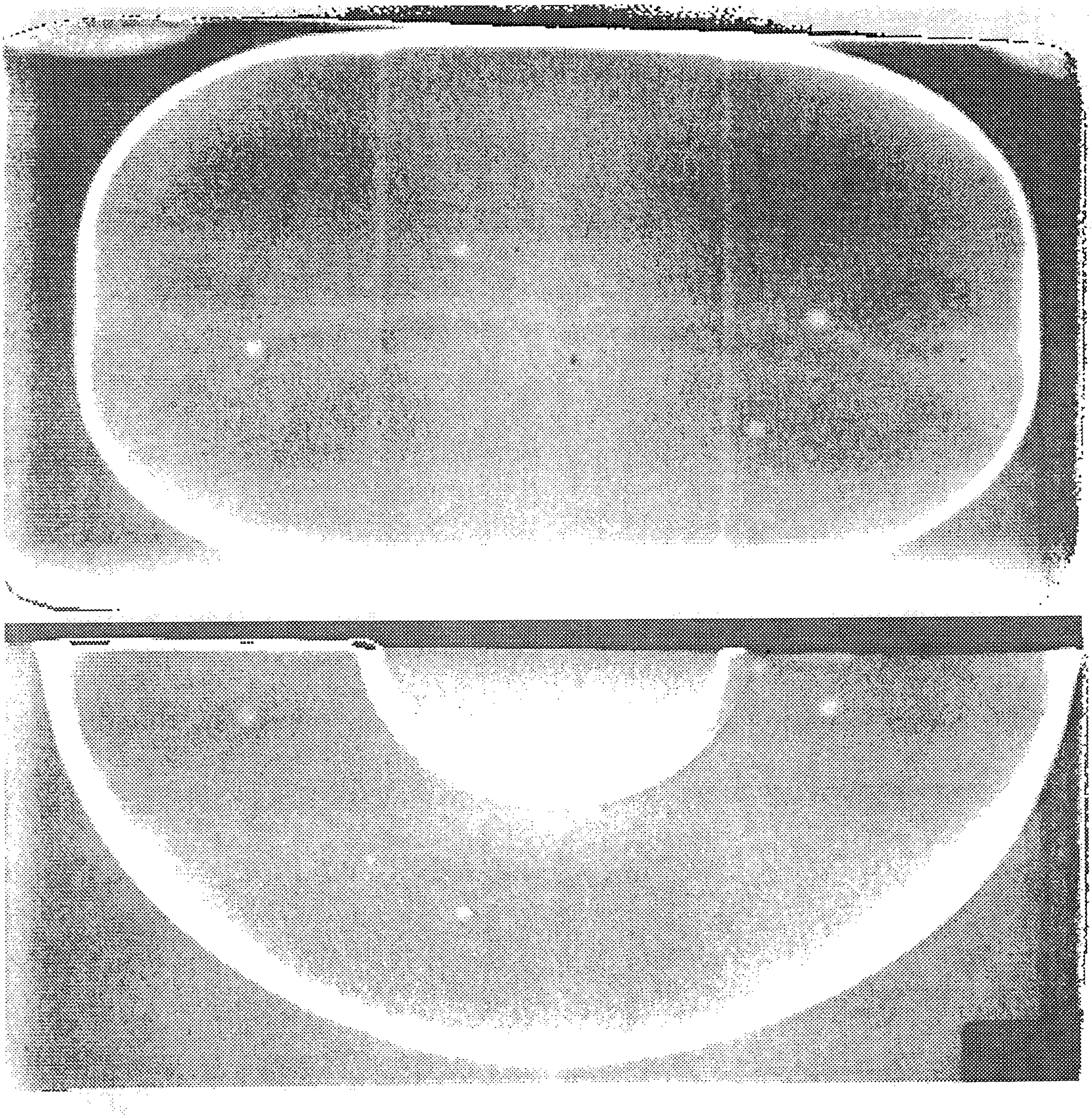


TABLE 2. SAMPLE PROCESSING OUT PUT
(Images #93 thru #110)

```
    centerx centery area/500 hsz/vsz area/box lmn/gmn lvr/256 per*per-4
  pi*area fr_dim y/n
0093_( 0.76367 0.06452 0.01600 1.33333 0.66667 1.17687 0.05859 1.43240
0.00000 0 1)
0095_( 0.78711 0.07056 0.03600 1.20000 0.60000 1.72059 0.07031 1.37555
2.78246 0 1)
0096_( 0.80469 0.08669 0.42000 1.51724 0.16458 3.70732 0.04688 5.20937
2.30883 0 1)
0098_( 0.81055 0.08871 0.37400 1.38462 0.19979 3.89744 0.04297 3.85634
2.35930 0 1)
0101_( 0.62695 0.47984 0.08600 1.00000 0.67188 1.11957 0.04688 1.38396
2.40346 0 1)
0103_( 0.82812 0.09677 0.14400 1.28571 0.28571 3.13636 0.03906 2.42083
2.61059 0 1)
0103_( 0.84375 0.36895 0.12200 1.12500 0.84722 1.47826 0.02344 1.23883
2.45948 0 1)
0104_( 0.82422 0.09476 0.21600 1.36842 0.21862 4.46667 0.04688 3.43007
2.48666 0 1)
0104_( 0.38086 0.29435 0.14600 0.90909 0.66364 1.95833 0.02344 0.93544
2.50627 0 1)
0104_( 0.80859 0.43347 0.12400 1.37500 0.70455 1.24074 0.02344 1.07940
2.49957 0 1)
0105_( 0.40039 0.21371 0.10800 1.25000 0.67500 1.58140 0.03125 1.06345
2.51715 0 1)
0105_( 0.71484 0.27823 0.12000 1.00000 0.74074 2.03226 0.03125 1.13774
2.53496 0 1)
0105_( 0.22070 0.30242 0.09400 1.12500 0.65278 1.87179 0.02344 1.17893
2.55308 0 1)
0105_( 0.66016 0.37702 0.10400 1.12500 0.72222 1.91304 0.02734 1.13205
2.55939 0 1)
0106_( 0.50000 0.31250 0.03800 0.83333 0.63333 0.51020 0.03516 1.20361
2.73324 0 1)
0107_( 0.83008 0.09879 0.18000 1.25000 0.28125 3.85294 0.05078 2.37328
2.56995 0 1)
0110_( 0.82031 0.09476 0.28600 1.40000 0.25536 4.17143 0.04688 3.14940
2.45618 0 1)
```

Appendix E presents the processing outputs for all 1479 x-ray images. The results of grouping the images, identifying defects, and processing (anomalies found) are presented in Table 3. Only the side view packet was processed. Further refinement of the approach could include correlation of data from the two views. Images #1, 8, 223, 224, and 1479, containing calibration disks were excluded from this part of the analysis and were not counted in number of defects and anomalies.

TABLE 3. PROCESSING RESULTS BY SET
(1479 x-ray images)

Set #	Image #	# Defects	# Anomalies
1	1 - 250*	36	253
2	251 - 500	18	231
3	501 - 750	75	278
4	751 - 1000	13	244
5	1001 - 1250	62	304
6	1251 - 1279**	24	200

* Excludes Images #1, 8, 223 & 224
** Excludes Image #1479

III.2. ANN TRAINING

As described in Section II.3.4, the "NETS" system was trained to perform automated defect recognition. The output of the processing steps/features vector for each anomaly provided the input which, in the training phase, mapped out to the corresponding output, ground truth, for each anomaly. The data from x-ray images contained in sets #1, #2, and #6 were used in training the ANN. To identify the effect of peculiarities in each set and the smoothing effect from larger numbers of training sets, four (4) training packages were used as follows: (1) Set #1, (2) Set #2, (3) Set #1 + 2, and (4) Sets #1 + 2 + 6.

Table 4 shows a subset of the training input from Set #1 (Images #93 through #110) corresponding to the processing output shown in Table 2. Note the image number has been suppressed and the last two values (All 0, 1 in Table 2), corresponding to the probability of the anomaly being a defect and not being a defect, have been changed according to the ground truth. Appendix F presents printouts of all input data for training Sets #1, #2, and #6.

TABLE 4 SAMPLE ANN TRAINING INPUTS
Set #1 (Images #93 - #110)

```
centerx centery area/500 hsz/vsz area/box lmn/gmn lvr/256 per*per-4
pi*area fr_dim y/n
( 0.76367 0.06452 0.01600 1.33333 0.66667 1.17687 0.05859 1.43240 0.000
00 0 1)
( 0.78711 0.07056 0.03600 1.20000 0.60000 1.72059 0.07031 1.37555 2.782
46 0 1)
( 0.80469 0.08669 0.42000 1.51724 0.16458 3.70732 0.04688 5.20937 2.308
83 0 1)
( 0.81055 0.08871 0.37400 1.38462 0.19979 3.89744 0.04297 3.85634 2.359
30 0 1)
( 0.62695 0.47984 0.08600 1.00000 0.67188 1.11957 0.04688 1.38396 2.403
46 0 1)
( 0.82812 0.09677 0.14400 1.28571 0.28571 3.13636 0.03906 2.42083 2.610
59 0 1)
( 0.84375 0.36895 0.12200 1.12500 0.84722 1.47826 0.02344 1.23883 2.459
48 1 0)
( 0.82422 0.09476 0.21600 1.36842 0.21862 4.46667 0.04688 3.43007 2.486
66 0 1)
( 0.38086 0.29435 0.14600 0.90909 0.66364 1.95833 0.02344 0.93544 2.506
27 1 0)
( 0.80859 0.43347 0.12400 1.37500 0.70455 1.24074 0.02344 1.07940 2.499
57 1 0)
( 0.40039 0.21371 0.10800 1.25000 0.67500 1.58140 0.03125 1.06345 2.517
15 1 0)
( 0.71484 0.27823 0.12000 1.00000 0.74074 2.03226 0.03125 1.13774 2.534
96 1 0)
( 0.22070 0.30242 0.09400 1.12500 0.65278 1.87179 0.02344 1.17893 2.553
08 1 0)
( 0.66016 0.37702 0.10400 1.12500 0.72222 1.91304 0.02734 1.13205 2.559
39 1 0)
( 0.50000 0.31250 0.03800 0.83333 0.63333 0.51020 0.03516 1.20361 2.733
24 0 1)
( 0.83008 0.09879 0.18000 1.25000 0.28125 3.85294 0.05078 2.37328 2.569
95 0 1)
( 0.82031 0.09476 0.28600 1.40000 0.25536 4.17143 0.04688 3.14940 2.456
18 0 1)
```

III.3. TEST RESULTS

Image Sets #3, #4, and #5 were used to test the prototype DAXIS system. Table 5 presents the combinations of training sets/test sets used in the basic analysis and two side studies. Table 6 presents sample inputs/feature vector for a group of anomalies from test set #5 (Images #1023 - #1026) and the corresponding outputs from the ANN trained using set #1. Note that in the output sample, the checkmarks have been added to represent those anomalies that were identified as defects by the "experts" and that the defect/non-defect detection threshold values are no longer integers. The output of the processing for test sets #3, #4, and #5 presented in AppendixE were input to the ANN in the combinations of Table 5 after suppressing the image numbers. The outputs of the ANN trained using training sets #1 +2 + 6 for test sets #3, #4, and #5 are presented in Appendix G.

TABLE 5. TRAINING SETS/TEST SET COMBINATIONS

	Training Sets	Test Sets
Basic Processing & Feature Calculations	1 2 1+2 1+2+6	3, 5 3, 5 3, 5 3, 4, 5
Removed Fractal Dimensions Features	1	3
Calibration Disks Processing & Testing	1+ Image1 + Image8	Images 223, 224 + 1479

TABLE 6. ANN TEST -- INPUT AND OUTPUT
Set 5 (Images 1023-1026)

- **Sample Input**

```
1023_( 0.46680 0.27621 0.12800 1.33333 0.59259 1.35185 0.02734 1.27528
2.60048 0 1)
1023_( 0.37500 0.29435 0.10800 0.80000 0.67500 1.19512 0.02344 1.20361
2.50171 0 1)
1023_( 0.42773 0.29637 0.34400 1.46667 0.52121 1.08000 0.01562 2.15134
2.55685 0 1)
1023_( 0.18750 0.33266 0.13000 1.50000 0.67708 1.80556 0.02734 1.11797
2.58555 0 1)
1024_( 0.78320 0.07258 0.15200 1.72727 0.36364 2.68254 0.04297 2.79338
2.67614 0 1)
1024_( 0.82617 0.43145 0.10200 1.28571 0.80952 1.20000 0.02344 1.16979
2.48214 0 1)
1025_( 0.81836 0.09073 0.10800 1.20000 0.45000 2.37037 0.06641 1.71503
2.71362 0 1)
1025_( 0.16016 0.26411 0.53600 1.93333 0.61609 1.29730 0.01953 1.71604
2.53982 0 1)
1026_( 0.52734 0.25000 0.13000 1.00000 0.65000 1.25000 0.02344 1.11797
2.52755 0 1)
1026_( 0.29102 0.27016 0.16800 1.30000 0.64615 2.31250 0.02344 1.01775
2.52988 0 1)
1026_( 0.62695 0.30847 0.21200 1.08333 0.67949 2.75000 0.02344 1.18712
2.53266 0 1)
1026_( 0.33203 0.30645 0.12600 1.11111 0.70000 1.89655 0.02734 1.30884
2.57679 0 1)
```

- **Sample Output**

```
IMAGE=1023 AUA= 30 (239 ,137) result=(0.998792  0.001208) ✓
IMAGE=1023 AUA= 31 (192 ,145) result=(0.000038  0.999962) ✓
IMAGE=1023 AUA= 32 (218 ,146) result=(0.000072  0.999928) ✓
IMAGE=1023 AUA= 33 ( 96 ,164) result=(0.999654  0.000346) ✓
IMAGE=1024 AUA= 34 (400 , 35) result=(0.000000  1.000000)
IMAGE=1024 AUA= 35 (422 ,213) result=(0.253455  0.746545)
IMAGE=1025 AUA= 36 (419 , 45) result=(0.000016  0.999984)
IMAGE=1025 AUA= 37 ( 82 ,130) result=(0.000261  0.999740)
IMAGE=1026 AUA= 38 (269 ,124) result=(0.968910  0.031090) ✓
IMAGE=1026 AUA= 39 (149 ,133) result=(0.999999  0.000001) ✓
IMAGE=1026 AUA= 40 (320 ,153) result=(0.999077  0.000923) ✓
IMAGE=1026 AUA= 41 (169 ,151) result=(0.999993  0.000007) ✓
```

To assess system performance we plotted two values: (1) the probability of detection of defects (P_{DD})and (2) the probability of detection of false alarms (P_{FAS}), as a function of detection threshold value. The following equations were used:

$$P_{DD} = \frac{N_{DD}}{N_{DT}}$$

Where: N_{DD} ~ # of defects detected at detection threshold value
N_{DT} ~ # of defects in test set

$$P_{FAD} = \frac{N_{FAD}}{N_{DD} + N_{FAD}}$$

Where: N_{FAD} ~ # of false alarms detected

Figures 37, 38, 39, 40 and 41 present the resulting plots for training sets/test sets combinations: (1) TRS 1/TS-3, (2) TRS2/TS3, (3) TRS 1+2/TS3, (4) TRS 1+2+6/TS 3, and (5) TRS 1+2+6/TS 3+4+5, respectively. Note that these plots can be used to calculate the expected number of false alarms (N_{EFA}) and the expected number of defects missed (N_{EDM}) for a detection threshold value, given that one has the total number of "defects" detected (N_{DD} + N_{FAD}) using that detection threshold value.

Analysis of the results in terms of missed detections and false alarms showed that most occurred at very small anomaly size. Figures 42 and 43 show x-ray images #1023 and #1026 whose features vector and ANN results were presented in Table 6. While both images contain four identified defects, the middle two of image #1023 were not so classified by the system. Noting that the two defects missed were not as well defined in the side view than in the top view, and that only the side view was used by the system, it would seem that while correlation of results between side and top view would improve results, most of the misses can be traced to the nature of the feature vector used to characterize the defects. Area and other size-related features (such as variance within anomaly) become nonfactors at the sizes of defects involved (2x2 pixels or thereabouts) and fractal dimension could also become a nonfactor.

Misses (2 recorded) also occurred at the larger end of the spectrum, approaching calibration disk sizes. Figures 44 and 45 (Images #579 and #604, respectively) show the two examples recorded. The effect of size on threshold values used in processing was noted in the techniques evaluation phase of the study, and will be discussed later.

Review of images containing false alarms showed that in some instances the results could be due to inconsistencies in the identification of defects during building of the ground truth, that is defects were not labeled as such due to their size or were missed by the "experts."

To further investigate the results, two analyses were carried out. In the first instance, the fractal dimension feature was removed from the set of features vectors. The ANN was retained using training set #1 and tested using test set #3. The results are presented in Figure 46. The effect of the fractal dimension is readily apparent. More anomalies are being reported as false alarms and more certainty is reported in the detection of larger defects. Since the

Figure 37

PROBABILITY OF DETECTION vs. DETECTION THRESHOLD VALUE
[Training Set 1,   Test 3]

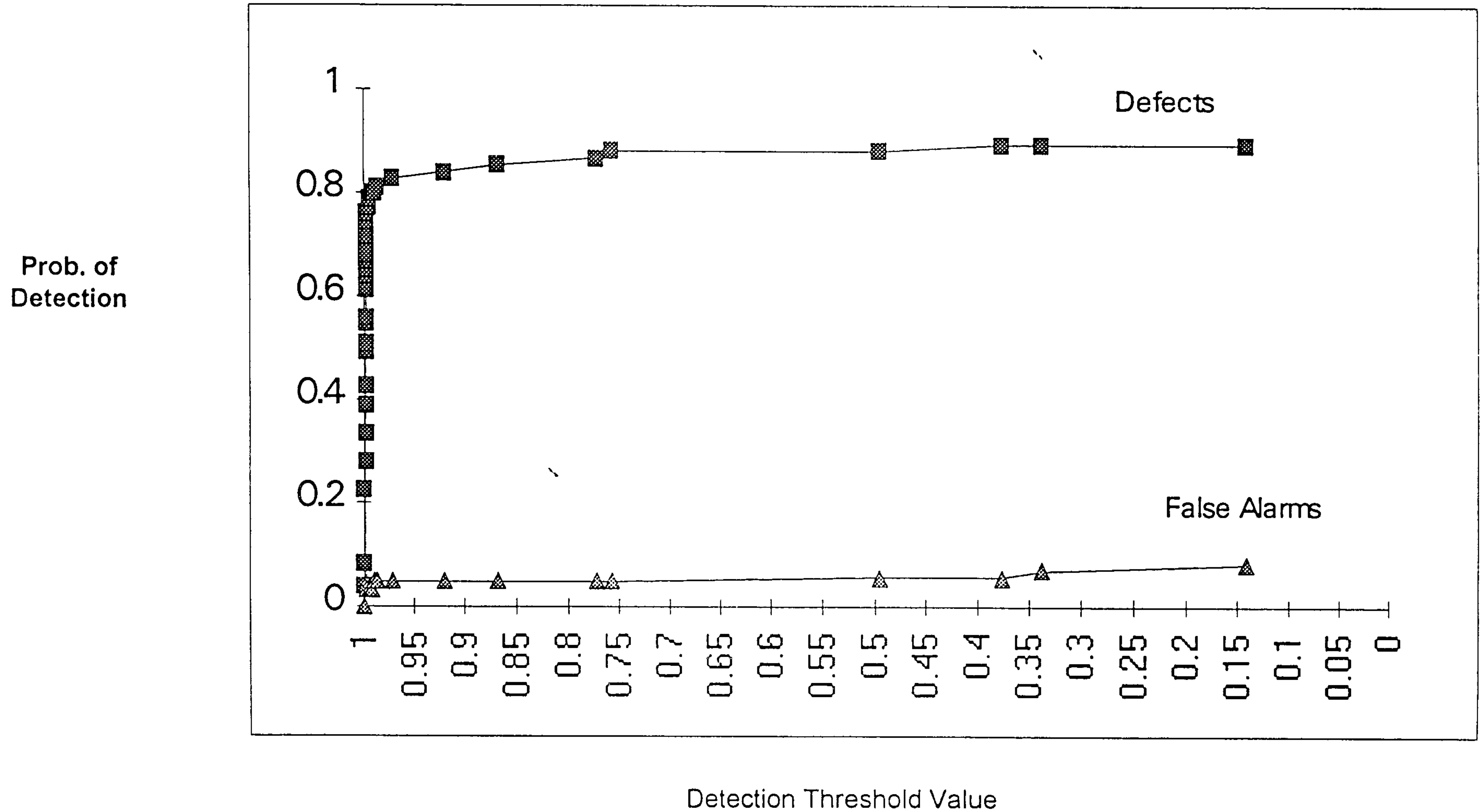


Figure 38

PROBABILITY OF DETECTION vs. DETECTION THRESHOLD VALUE
[Training Set 2,   Test 3]

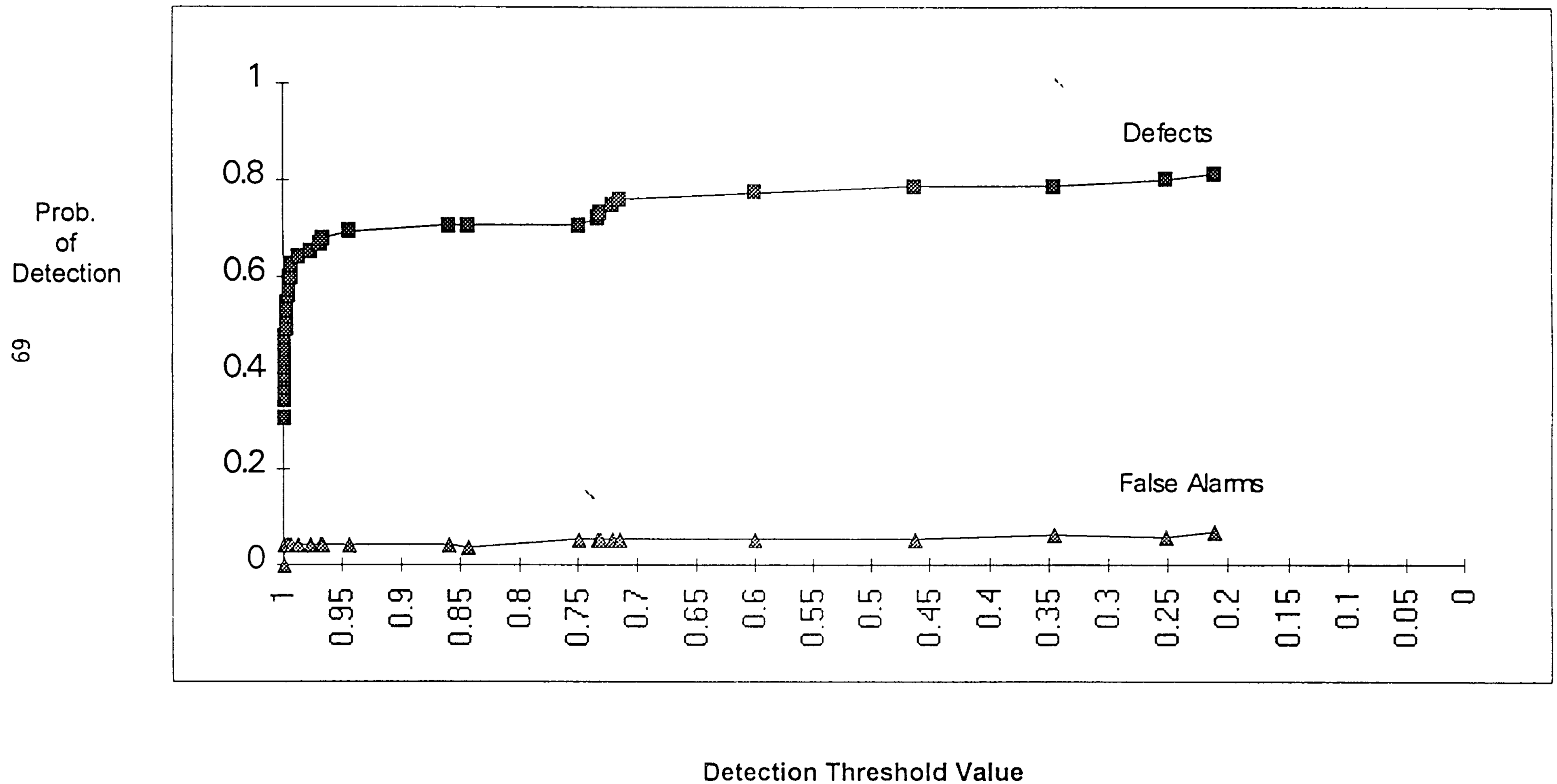


Figure 39

PROBABILITY OF DETECTION vs. DETECTION THRESHOLD VALUE
[Training Sets 1 & 2,   Test 3]

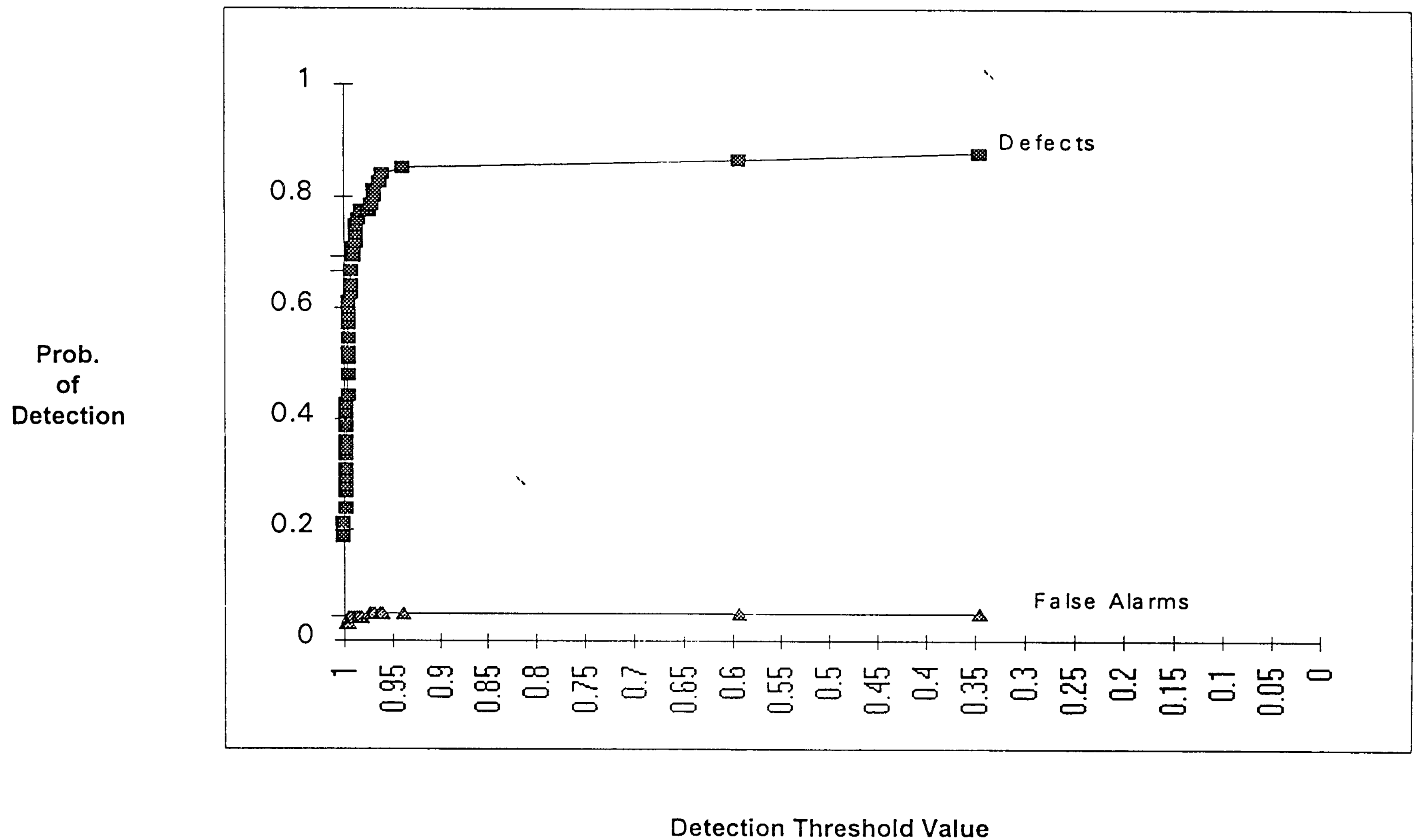


Figure 40

PROBABILITY OF DETECTION vs. DETECTION THRESHOLD VALUE
[Training Sets 1, 2 & 6, Test 3]

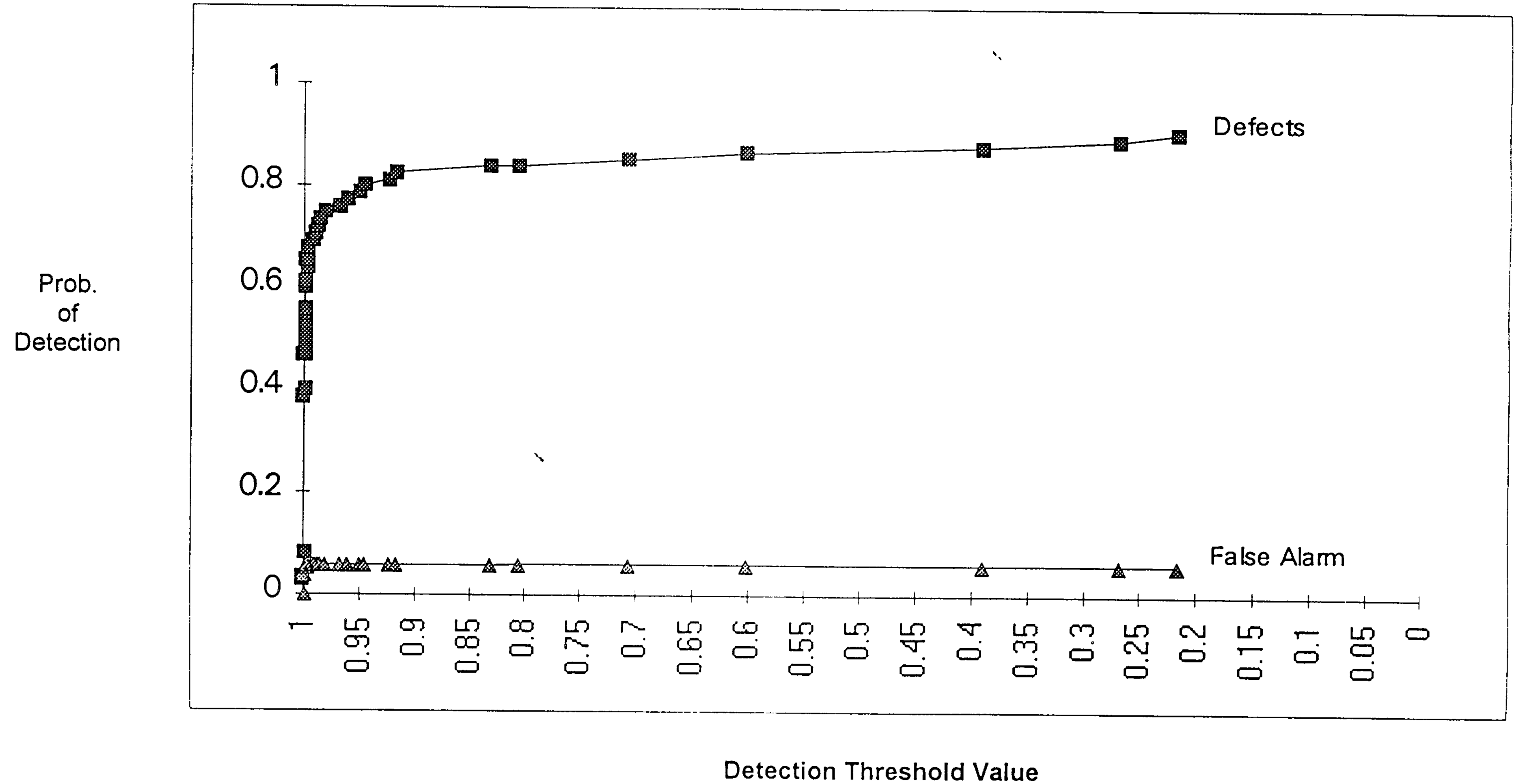


Figure 41

PROBABILITY OF DETECTION vs. DETECTION THRESHOLD VALUE [Training Sets 1, 2, & 6, Tests 3, 4, & 5]

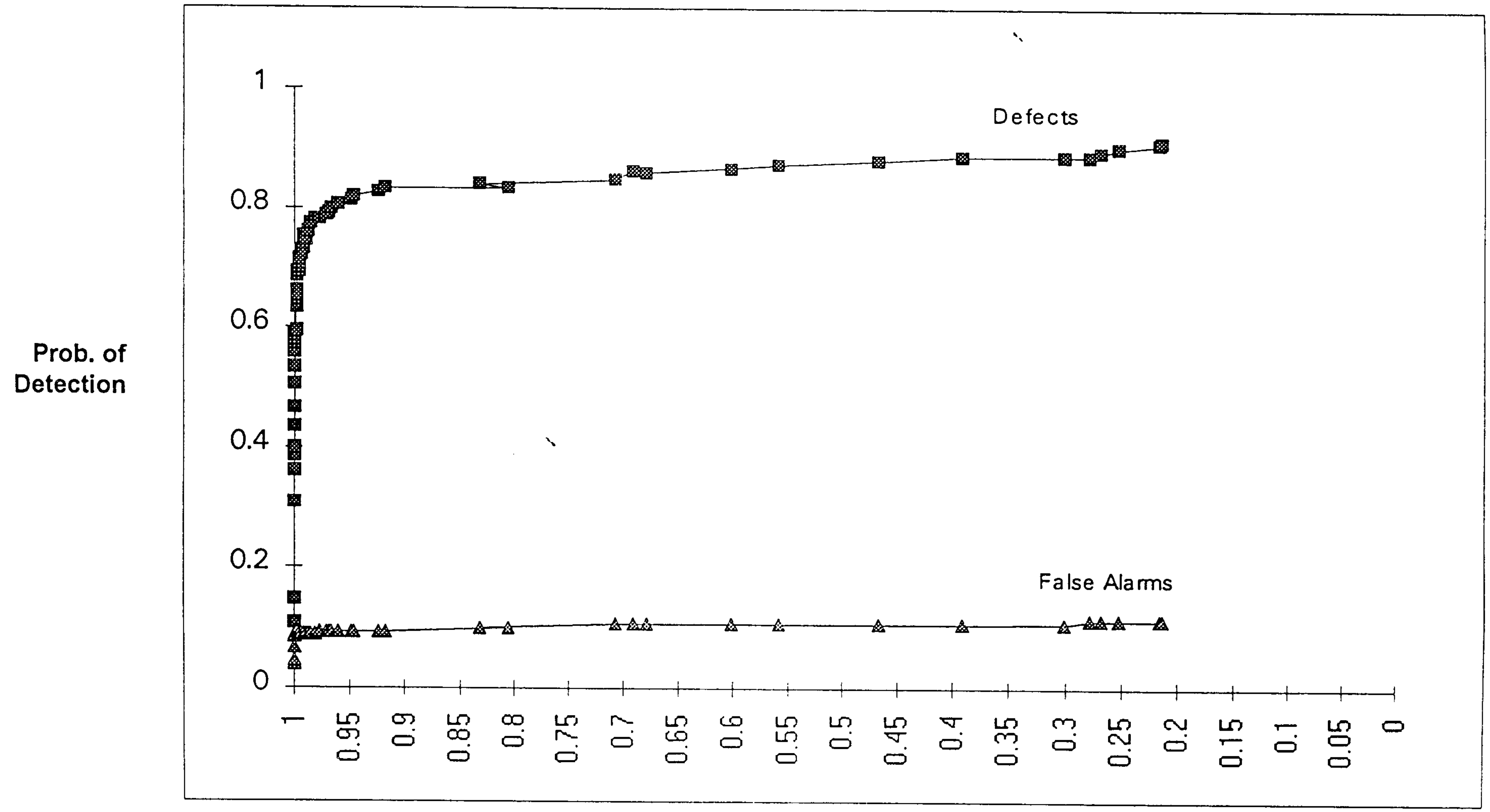


Figure 42

TEST RESULTS

Image #1023

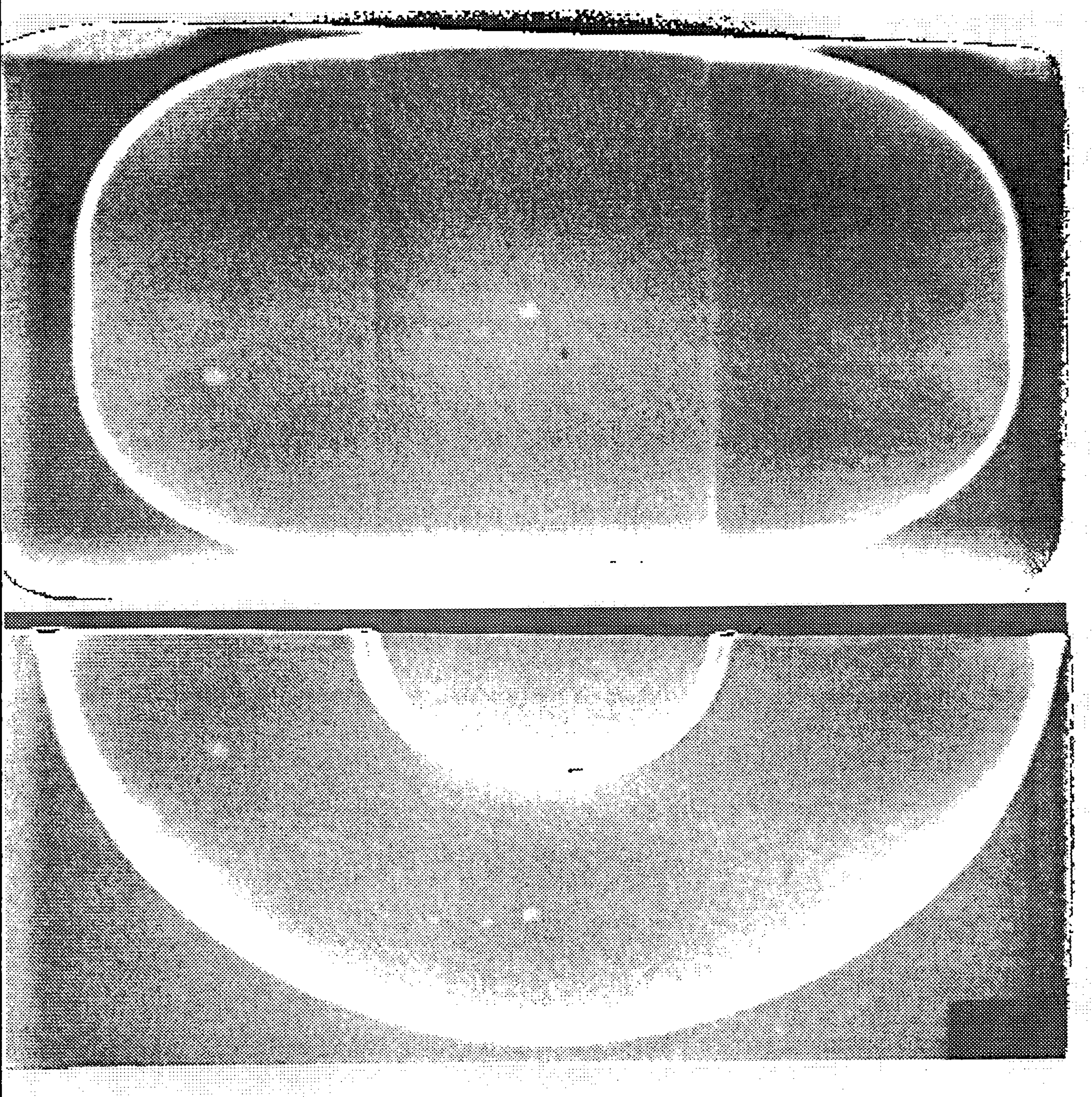


Figure 43

TEST RESULTS

Image #1026

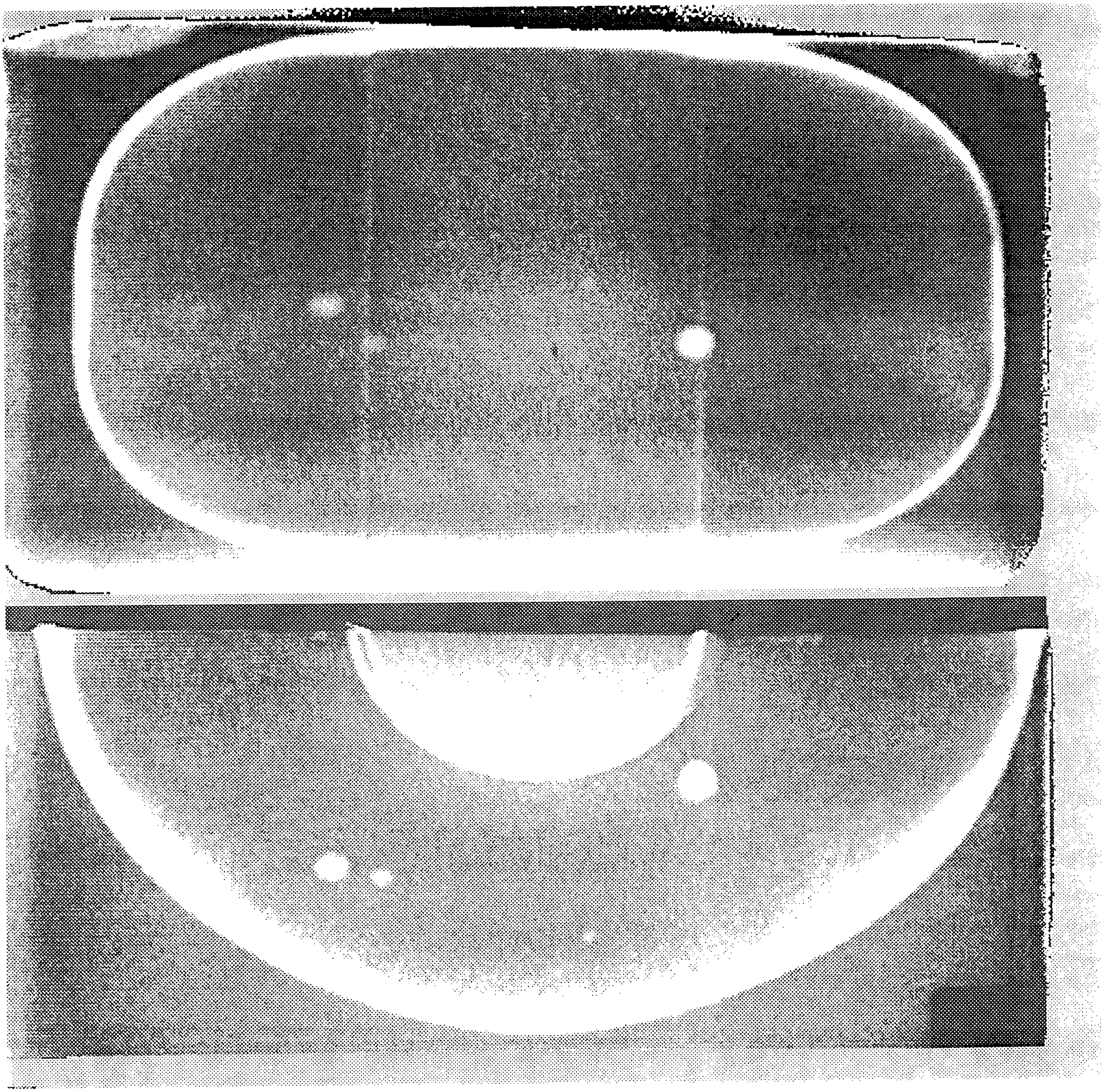


Figure 44

TEST RESULTS

Image #579

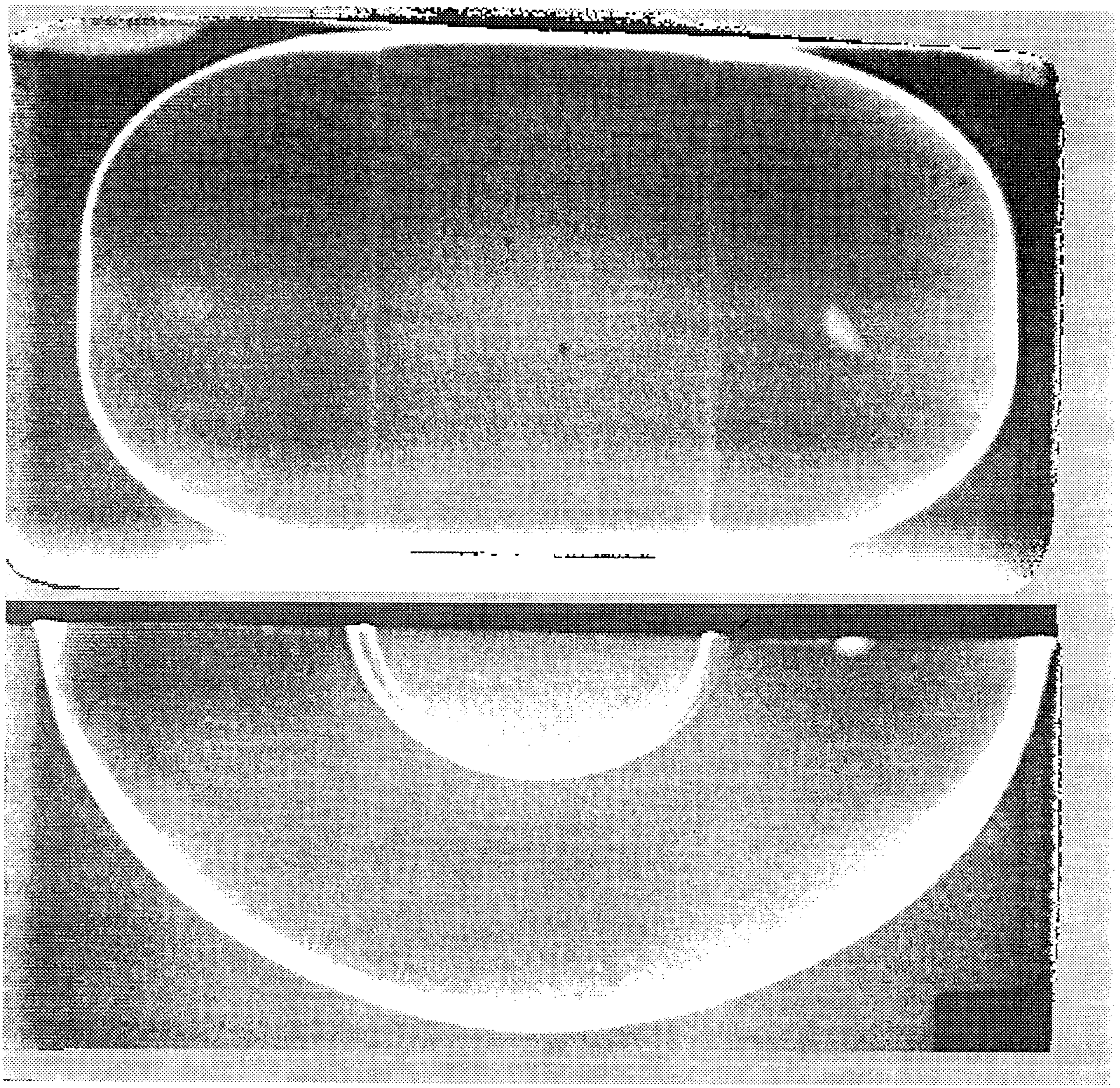


Figure 45

TEST RESULTS

Image #604

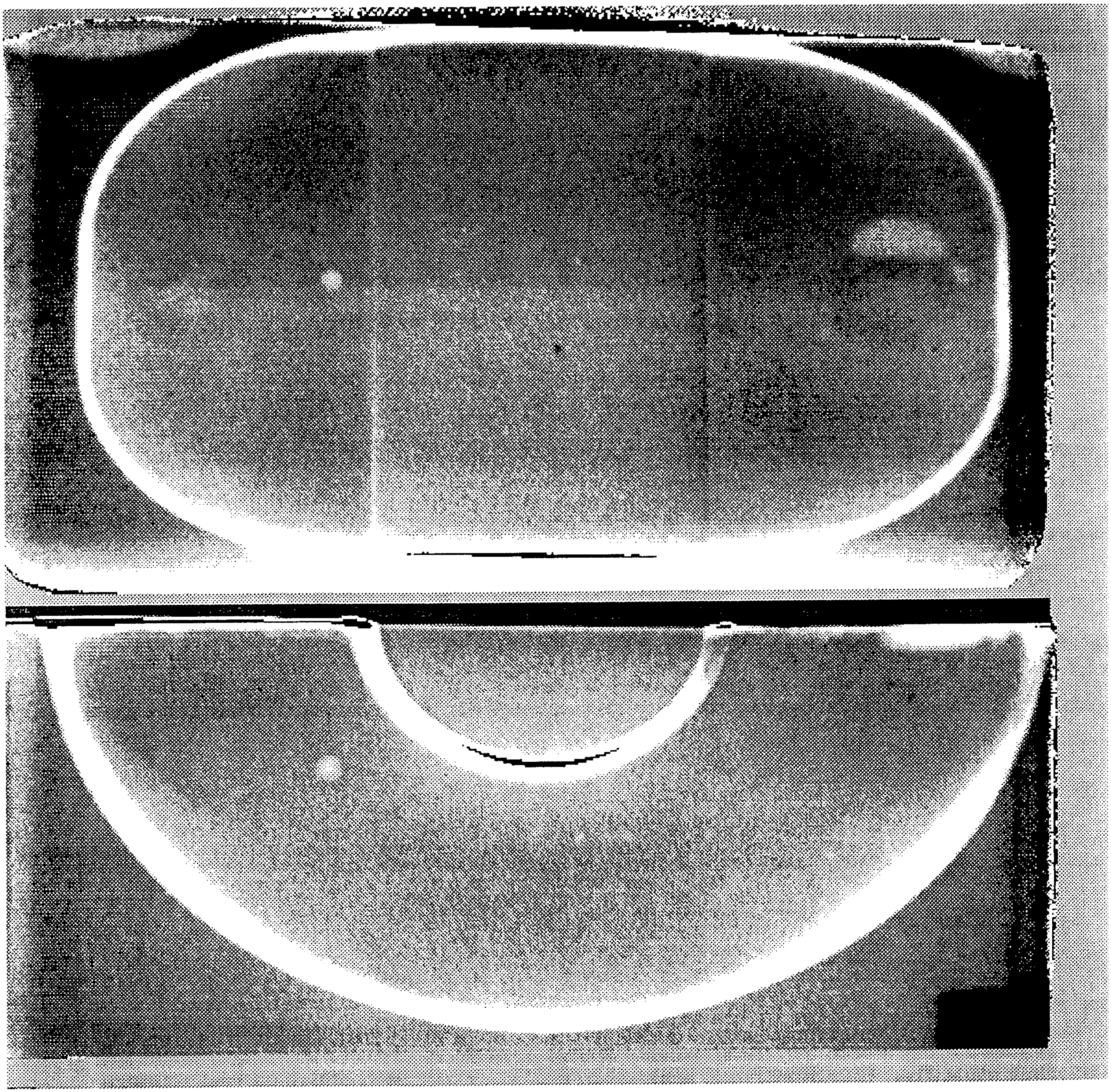
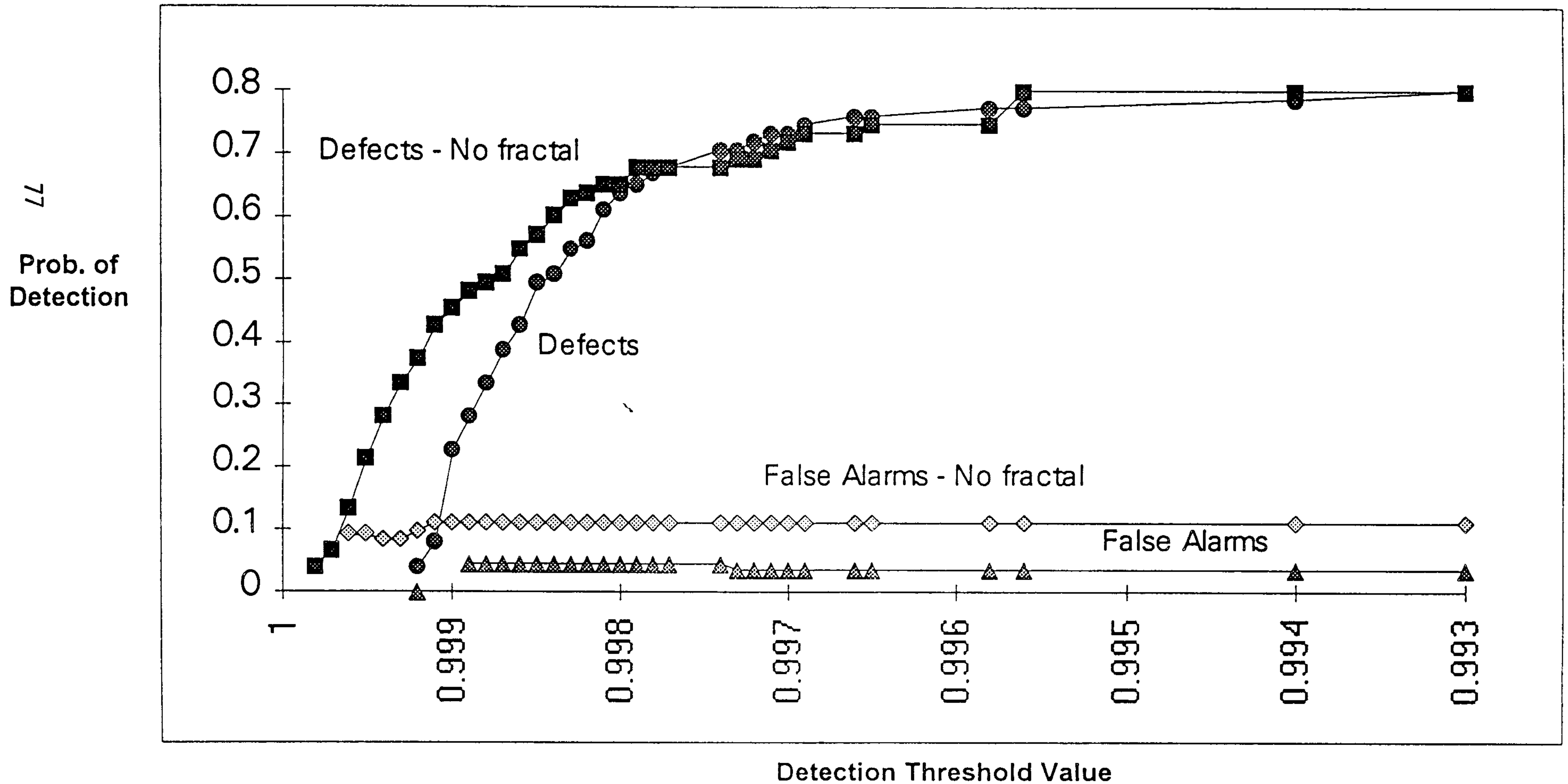


Figure 46

PROBABILITY OF DETECTION vs. DETECTION THRESHOLD VALUE
[Training Set 1, Test 3 {No Fractal Dimension}]



original false alarms and missed detections of very small anomalies was unaffected, it seems that fractal dimension is a nonfactor at very small sizes (< 3x3 pixesl).

The second analysis investigated detection of calibration disk sized defects. Note from Table 3 that images with calibration disks were excluded from the training and test sets. Table 7 summarizes the changes in training and test sets made and the results. Processing with the basic feature vector algorithms resulted in disks not being identified as anomalies. By adjusting the feature vectors calculations for larger objects and adding to the training set, only one (1) of sixty (60) disks (36 test/24 training) was misprocessed and a dramatic increase in probability of detection occurred.

TABLE 7. DETECTION RESULTS FOR CALIBRATION DISKS

Training Set 1 (No Calibrations Disk Images)
- Image 1479 processed
- 3 of 12 disks not identified in processing as anomalies
- 5 of 12 disks detected.

Training Set 1 plus Images #1 and #8 for Training
-- Variation growth threshold calculations

$$|P_i - P_k| \leq \text{ expected value}$$

- Images #223, #224, and #1479 as test sets
- 1 of 36 disks missed in processing
- Results by image
  - #223 - 9 detected; 3 not detected; 0 F.A.
  - #226 - 12 detected; 0 not detected; 0 F.A.
  - #2479 - 10 detected; 1 not detected; 2 F.A., 1 misprocessed

IV. REFERENCES

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[don94] Donoho, D.L., Johnstone, I., "Ideal Spatial Adaptation via Wavelet Shrinkage," *Biometrica*, 81:425-455, 1994.

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[rcg93] Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing," Addison Wesley, 1993.

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APPENDIX A

PHASE I SBIR SOLICITATION

A96-002 Title: Analysis of X-Ray Images using Wavelet and Fractal Methods

CATEGORY: Advanced Development

OBJECTIVE: Develop an x-ray data analysis system in which fractal and wavelet analysis methods are integrated with more traditional methods of analysis for analyzing x-ray multispectral images for identification of objects, object positions, and composition.

DESCRIPTION: The Army needs a limited but fairly numerous set of parameters that could be quickly calculated from x-ray radiographic images. The set of parameters must be adequate to identify and differentiate with a very high level of probability a host of materials both man-made and natural as seen in the radiographs.

The proposal should address the following unique attributes of the radio graphs. An x-ray radiographic image is the superimposed shadow of all materials between the x-ray source and the imaging device. To a large extent the pixel value or density is a function of the distance through an item normal to the image plane. Curvature of an item can be extracted from the change in the pixel values across an item. The edge of an item often is seen as a sudden change in the rate of change of intensity across the image. The complex effect of superposition may be partially calculated out through careful logic. Natural substances should portray a different fractal content than man-made objects. Consideration should be given to combining wavelet transformations with fractal analysis, and calculations of first and second order changes in intensity across image segments. The images to be analyzed are actually a set of images, each image consisting of a different spectral band. The different spectral images are all spatially registered.

PHASE I: The Phase I proposal must include a first set of parameters to be calculated and the basis for their choice. The proposal must demonstrate familiarity with radiographic images. The proposal must show a logical and realistic approach to determining an all encompassing set of parameters for identification of objects in radiographs. The Phase I objective will be to calculate the proposed set of parameters for a representative set of radiographs to be provided by the Army; to demonstrate how well they identify and differentiate items in the radiographs; and to propose a more appropriate and thorough set of parameters to be worked on in Phase II.

PHASE II: Develop, construct, test and deliver a complete set x-ray data analysis algorithms which meets the objective of the solicitation. All of the algorithms must be interfaced as a set of functions to the National Institute of Health's "NIH IMAGE" program and placed in the public domain. A second version must be interfaced to an Army custom x-ray image processing system. All algorithms must be designed to process both eight and sixteen bit data, and to process images of mega-pixels in size. Algorithms must be very fast.

POTENTIAL COMMERCIAL MARKET: Potential military and commercial applications include radiographic and tomographic inspection of munition items, vehicle components, manufactured items, and medical diagnosis. Algorithms developed for radiographs should have use for analysis of visible light and infrared images as well. Applications would include machine vision, target identification, robotics, and similar image analysis areas.

APPENDIX B

SEQUENCE OF FRUIT IMAGES

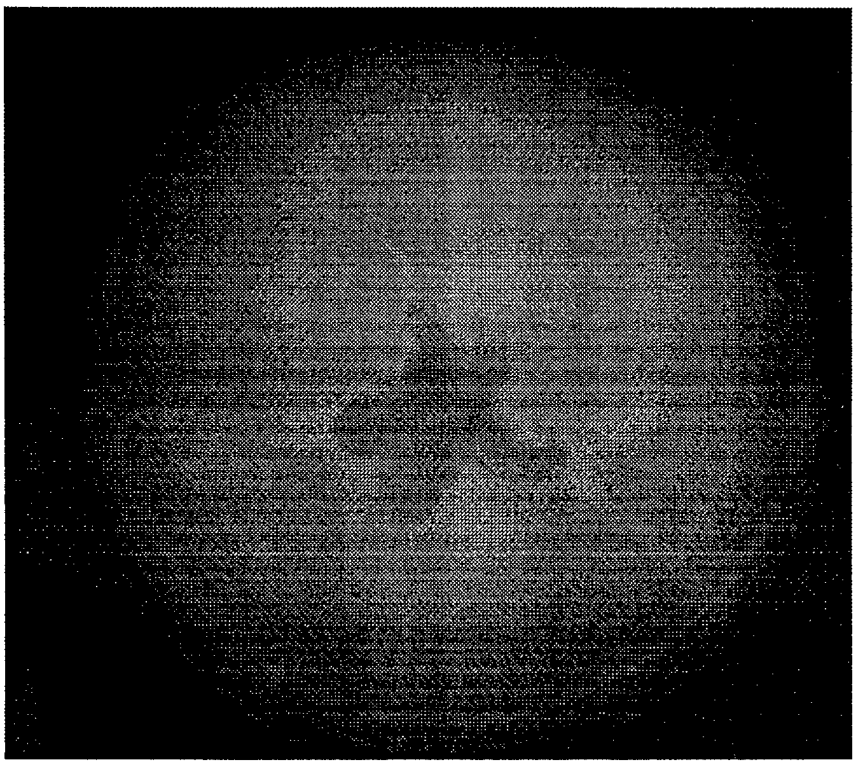


Figure B.1. Apple -- end-on view

Figure B.2. Tomato -- end-on view

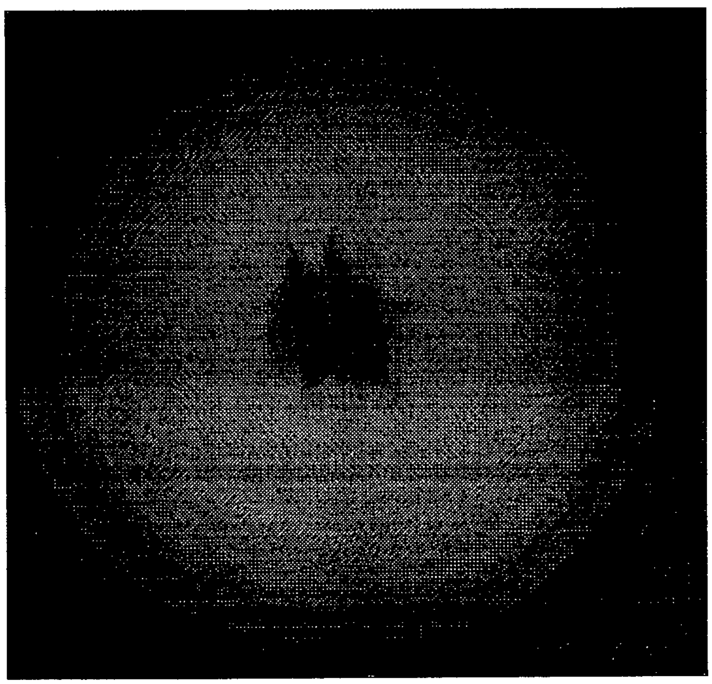


Figure B.3. Orange -- end-on view

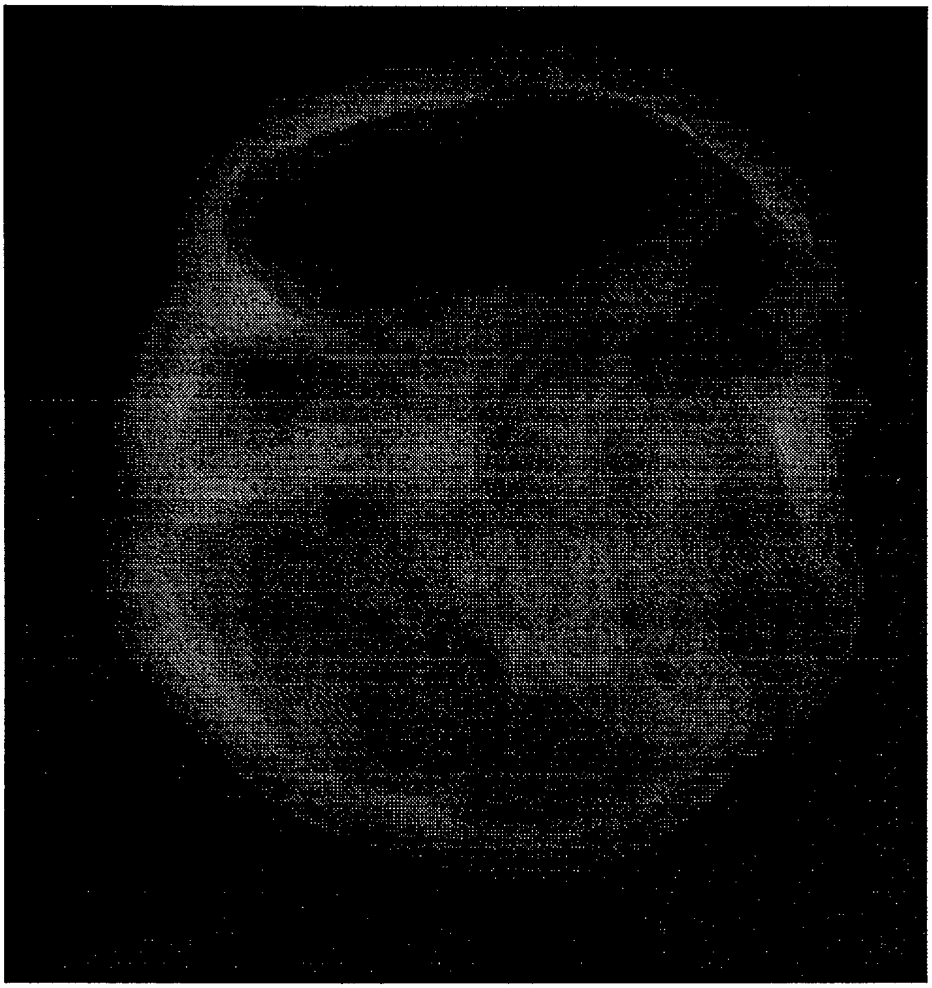


Figure B.4. Pepper -- end-on view

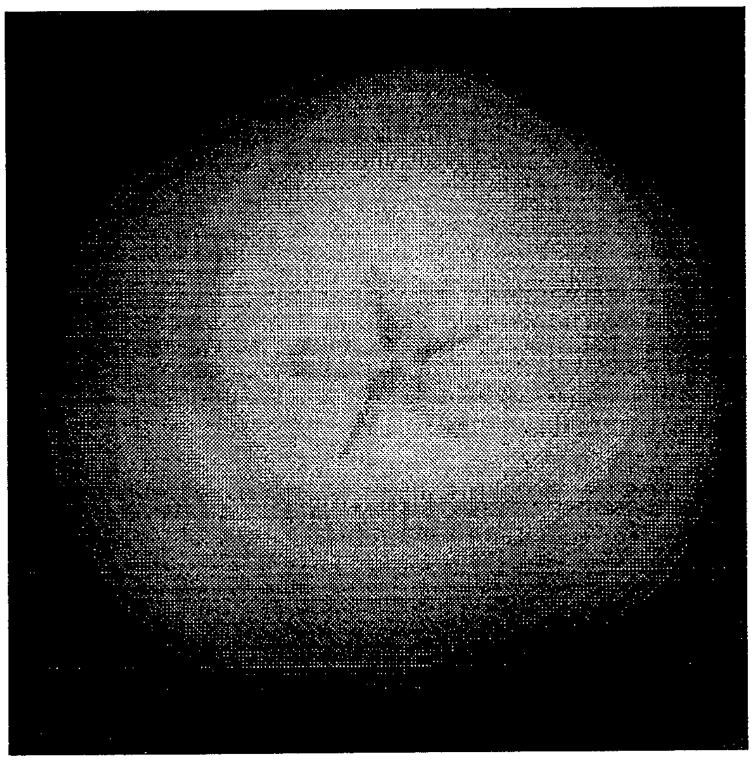


Figure B.5. Peach -- end-on view

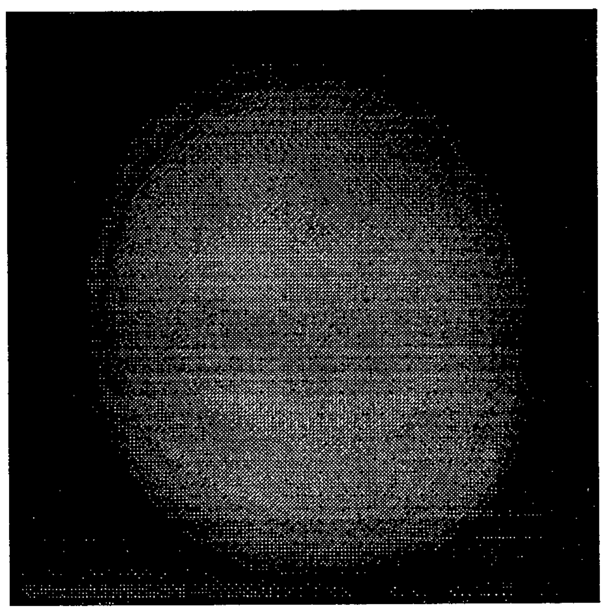


Figure B.6. Kiwi -- side view

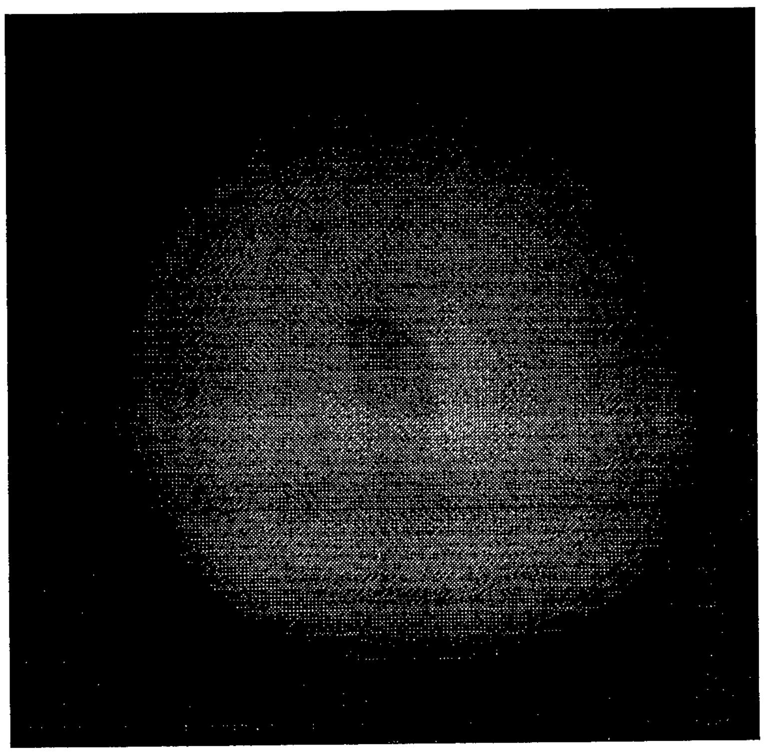


Figure B.7. Nectarine -- end-on view

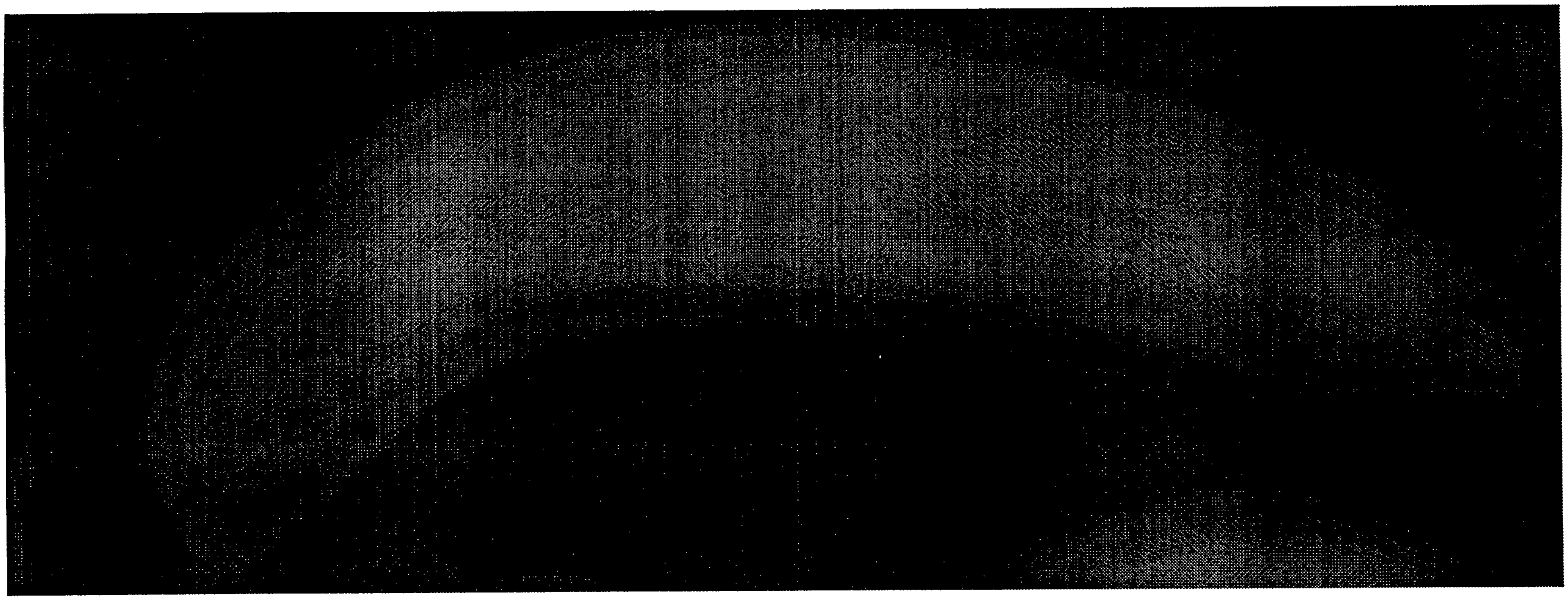


Figure B.8. Banana -- side view

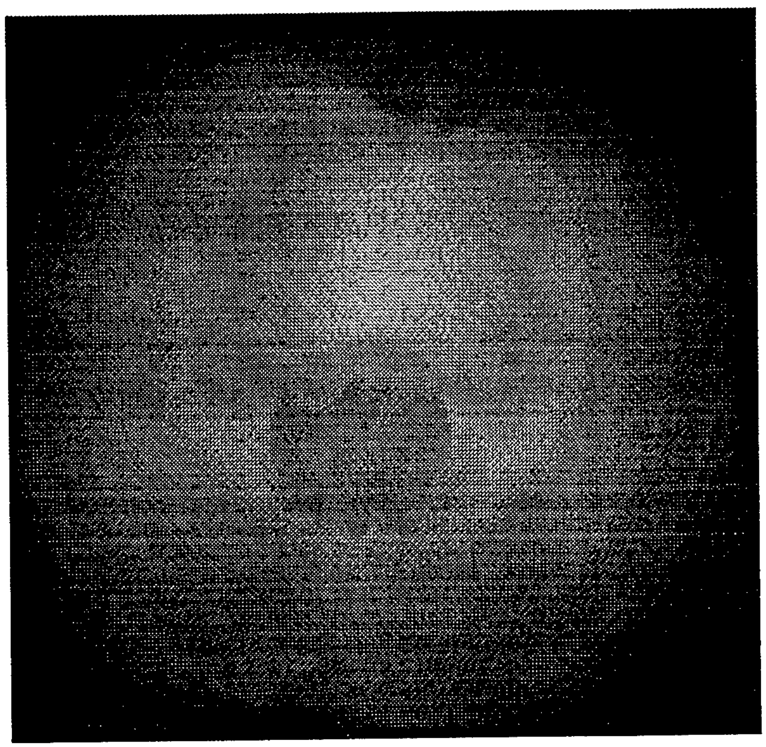


Figure B.9. Apple -- side view

APPENDIX C

REPRESENTATIVE MAMMOGRAMS FROM THE MIAS DATABASE

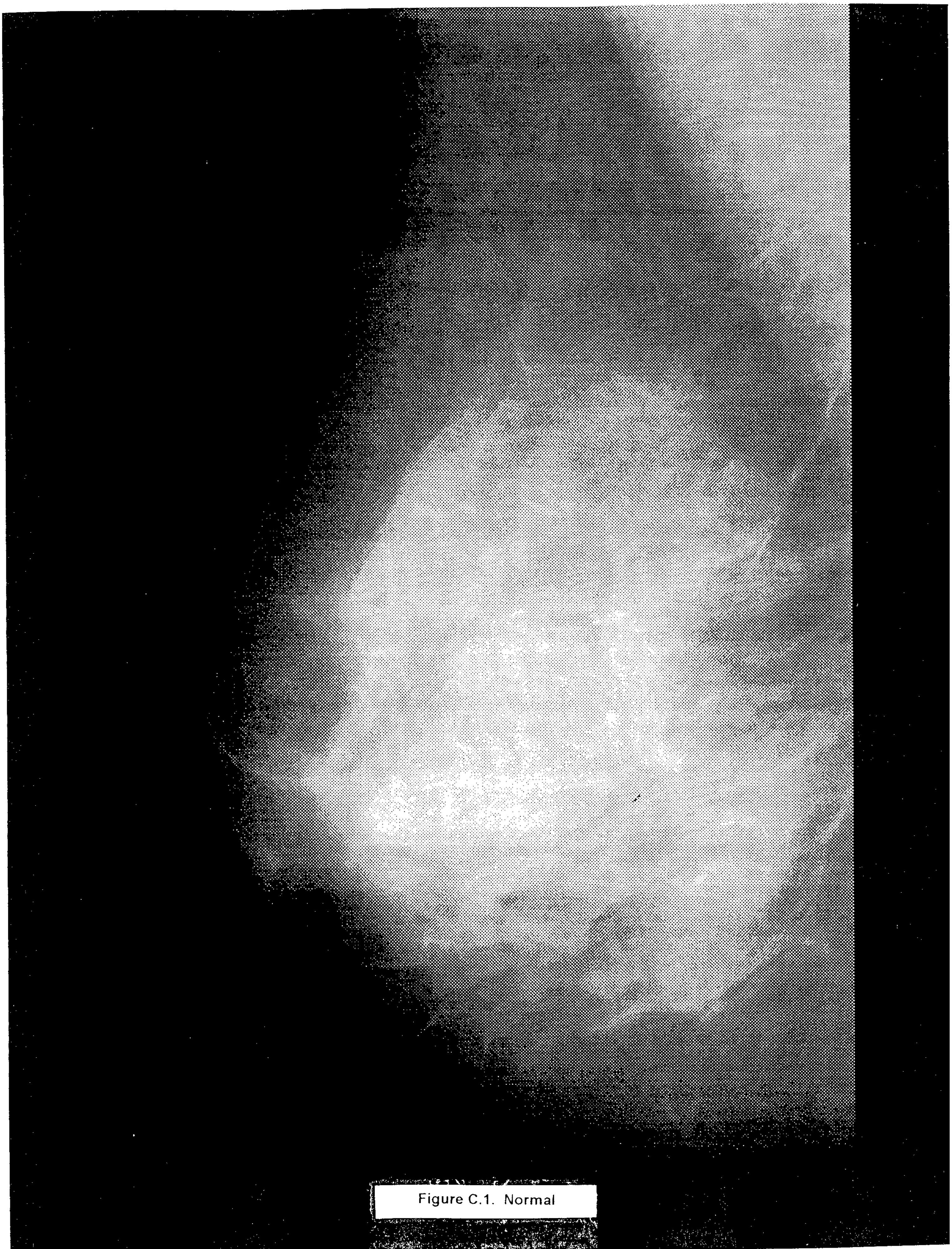


Figure C.1. Normal

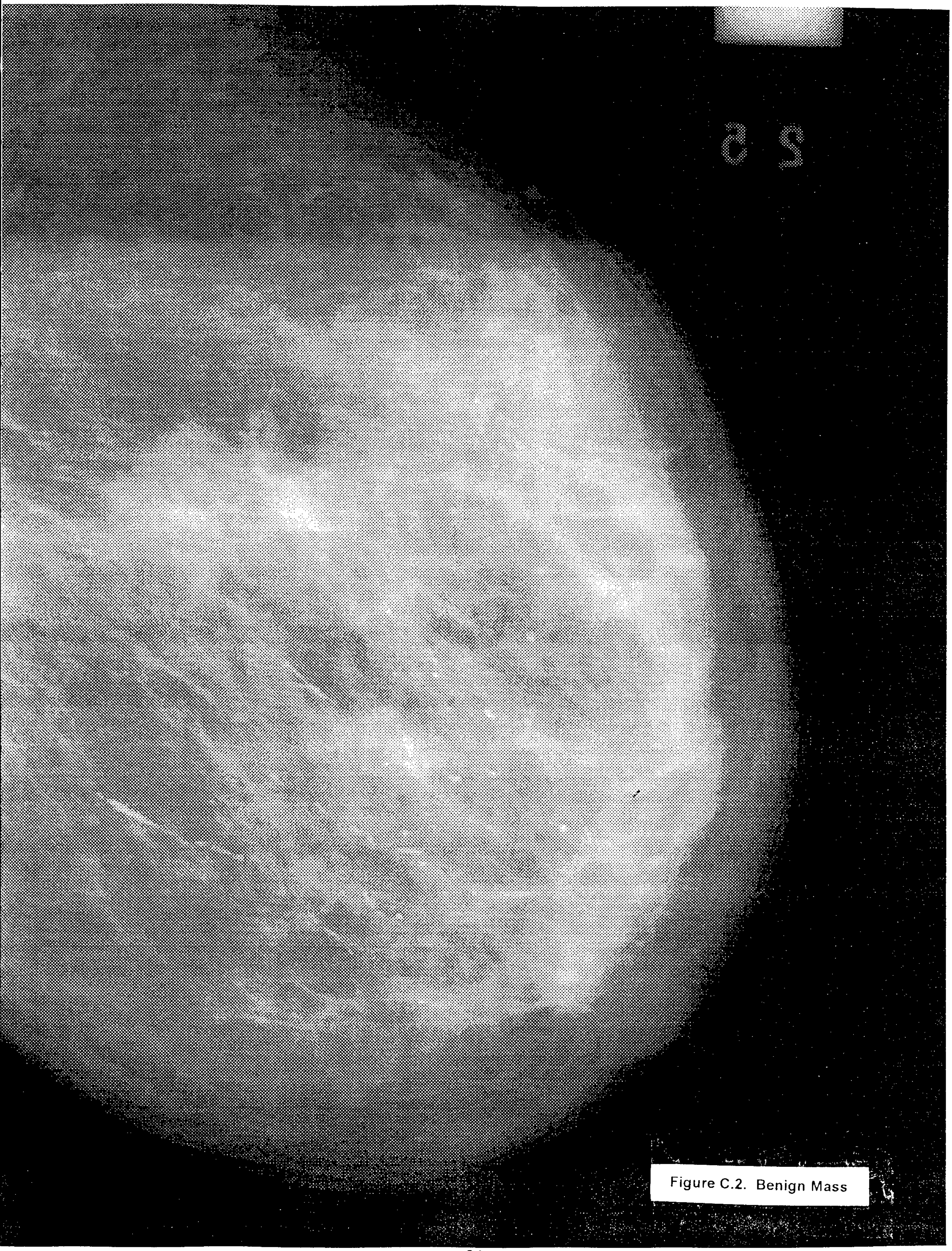


Figure C.2. Benign Mass

Figure C.3. Malignant Tumor

APPENDIX D

FRACTAL DIMENSION CALCULATIONS OF FRACTAL IMAGES AND FRUIT RADIOGRAPHS

The Sierginski Gasket is a classic fractal with a known dimension of d=log(3)/log(2)=1.585. The dimension measured by box-counting is 1.63.

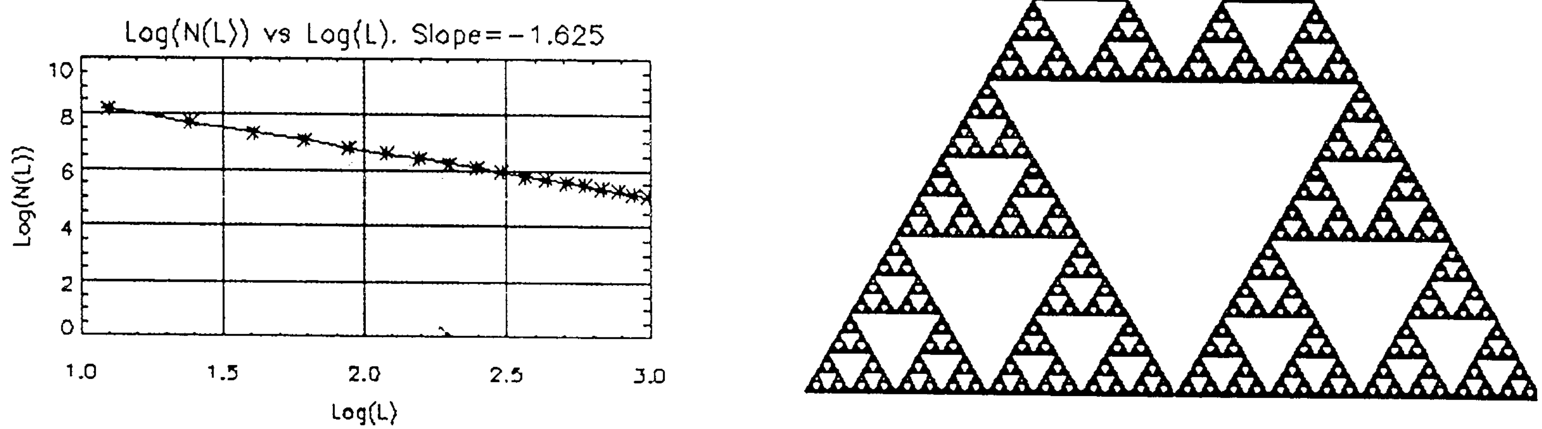
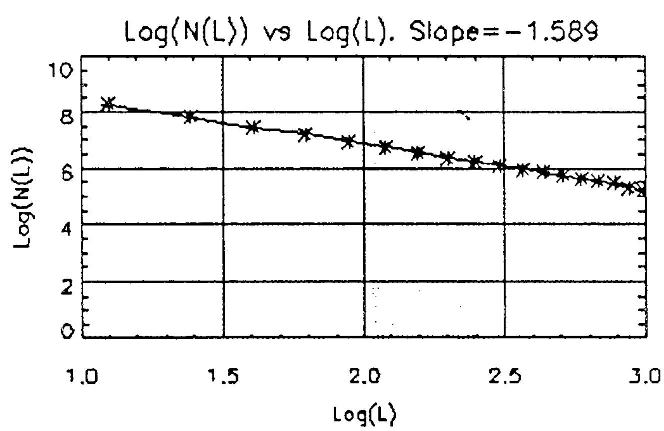


Figure D.1. Sierginski Gasket; FD = 1.585

The Sierginski Gasket A is a classic fractal with a known dimension of d=log(3)/log(2)=1.585. The dimension measured by box-counting is 1.589.



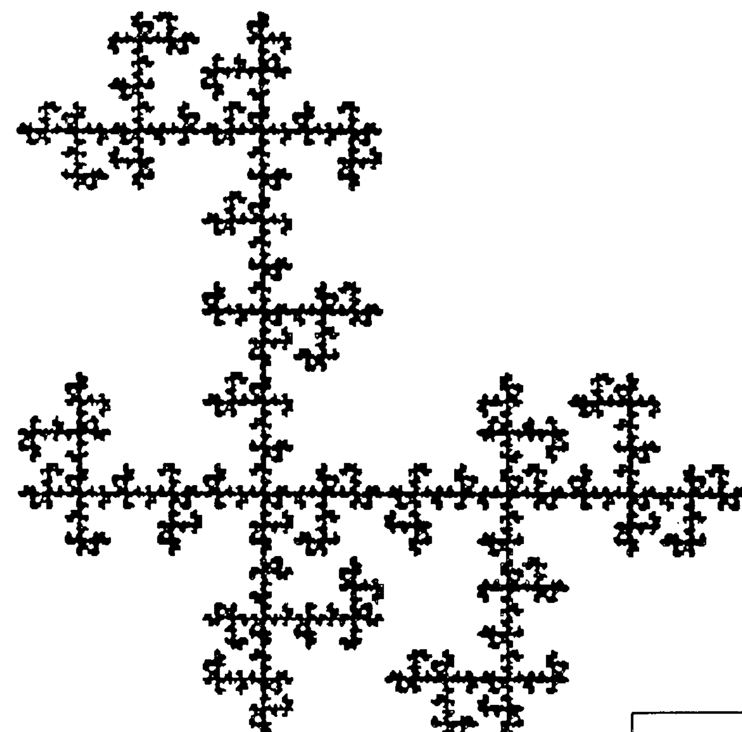


Figure D.2. Sierginski Gasket A; FD = 1.585

AnSim

Fractal constructed with n=8 affine transforms using a scaling ration of r=1/3. The fractal dimension is d=log(8)/log(3)=1.89. The measured dimension is 1.92.

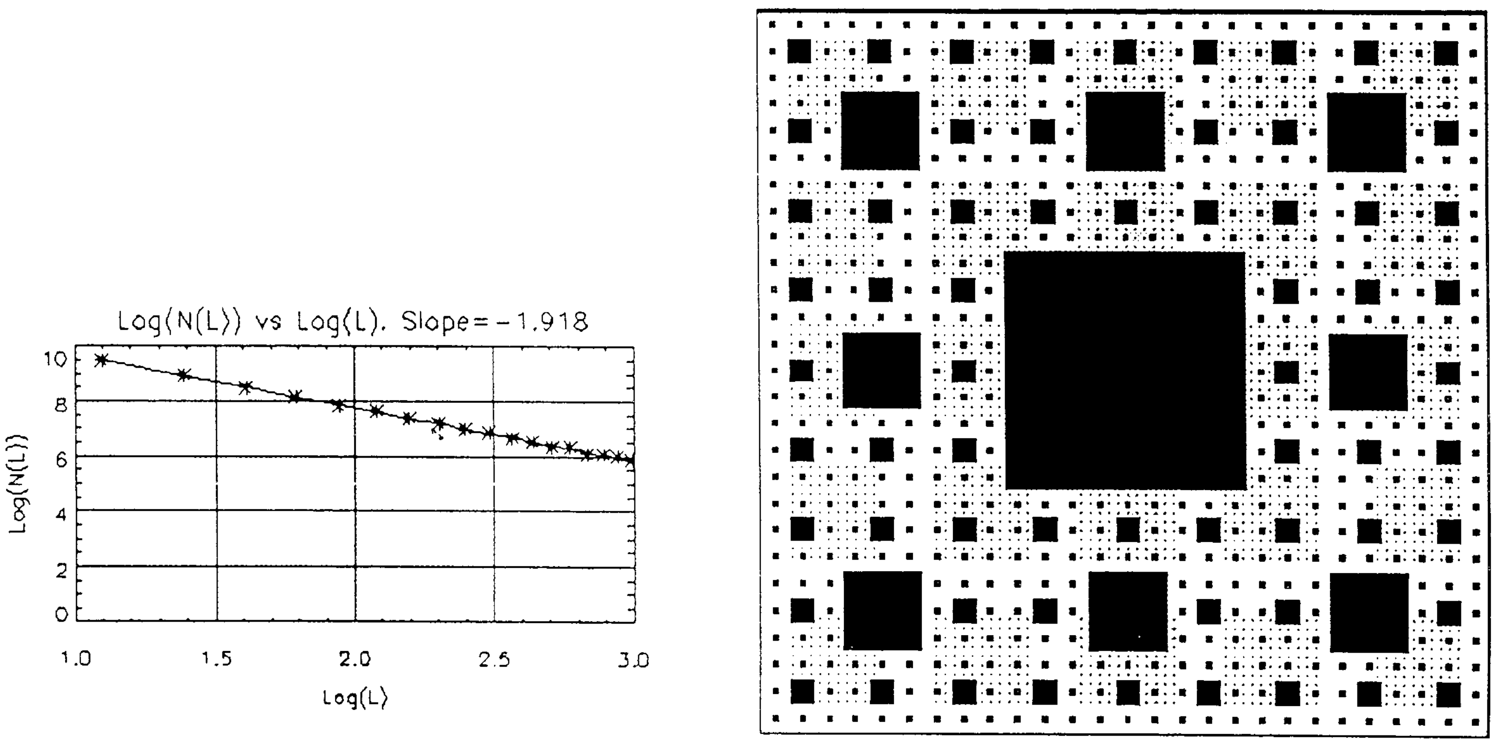
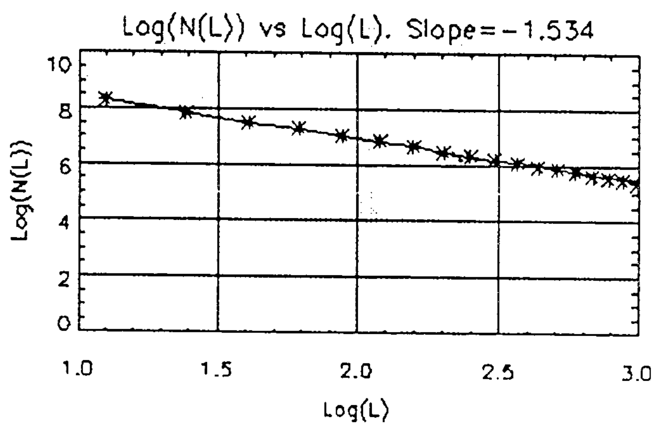


Figure D.3. Checkerboard; FD = 1.89

Checkerboard fractal constructed with n=8 affine transforms using a scaling ration of r=.25. The fractal dimension is d=log(8)/log(4)=1.5. The measured dimension is 1.53.



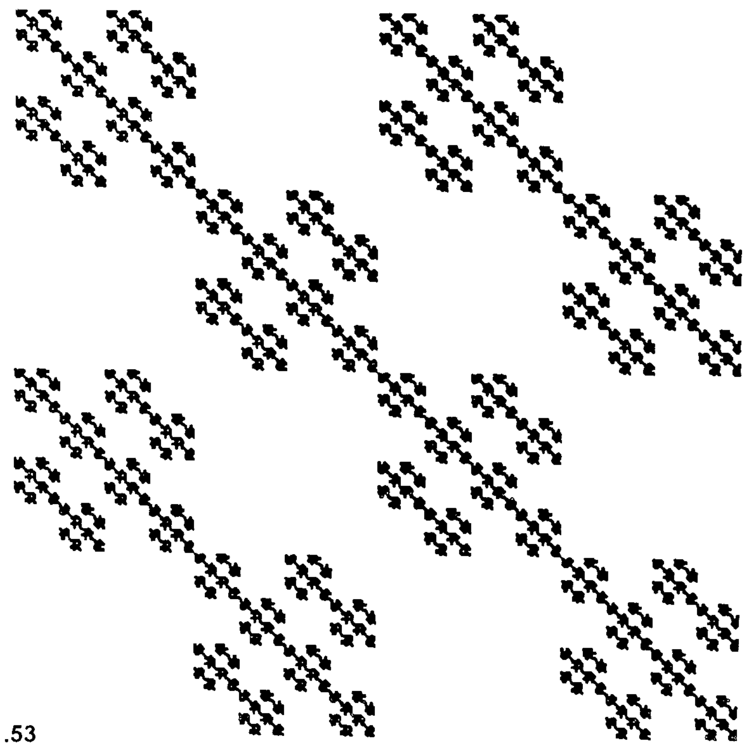
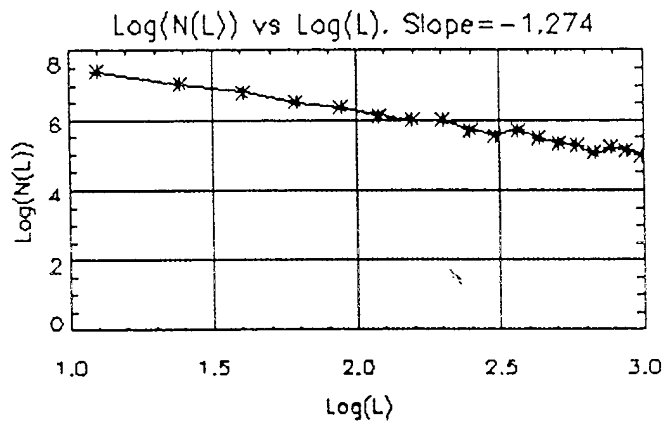


Figure D.4. Checkerboard; FD = 1.53

Fractal constructed with n=4 affine transforms using a scaling ration of r=1/3. The fractal dimension is d=log(4)/log(3)=1.26. The measured dimension is 1.27.



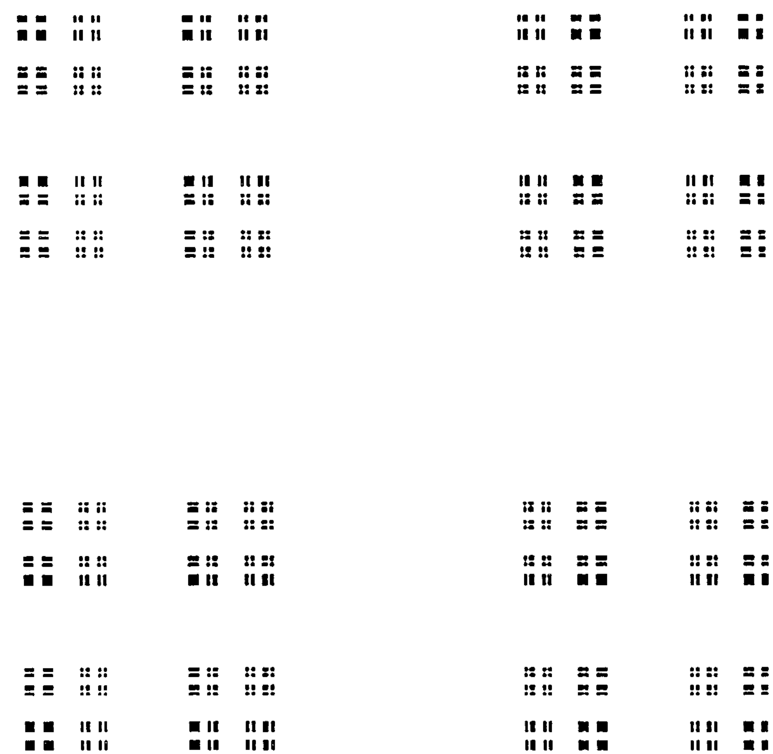
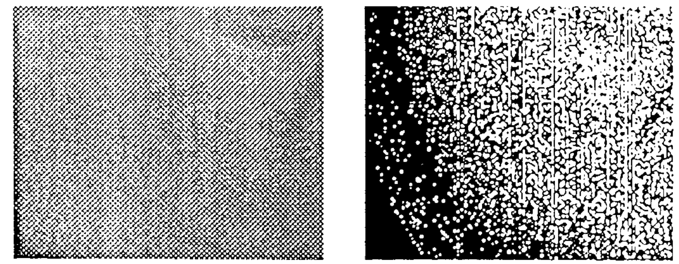
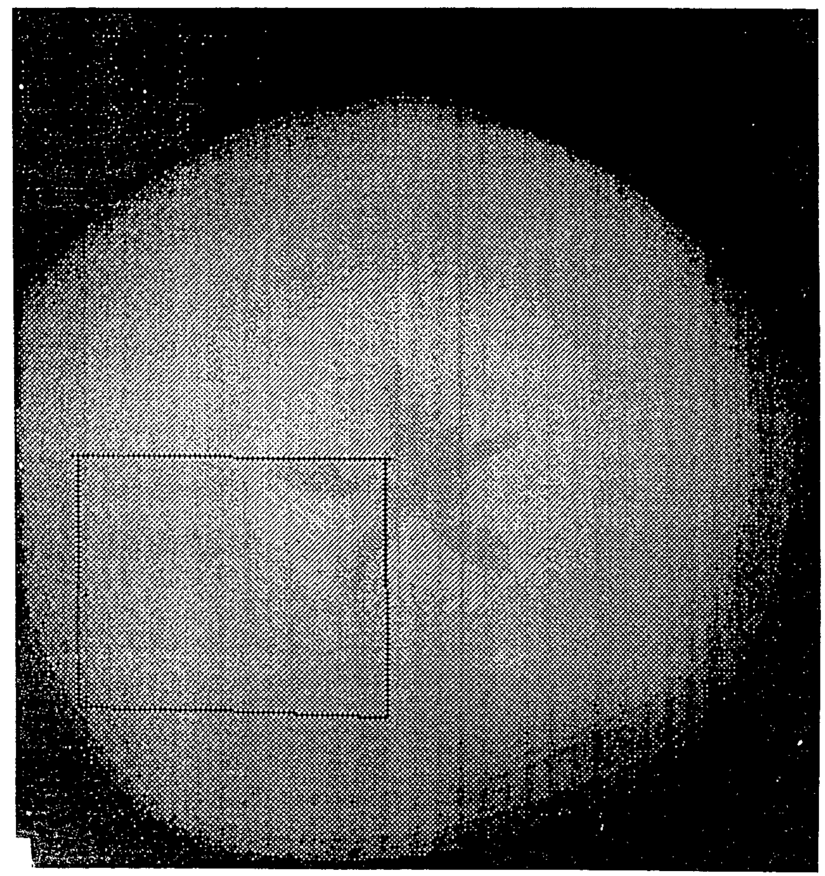


Figure D.5. Checkerboard; FD = 1.27

A section of the surface of a pear that has been enhanced by sharpening, edge detected, and binarization.. This surface has a fractal measure of approximately 1.96





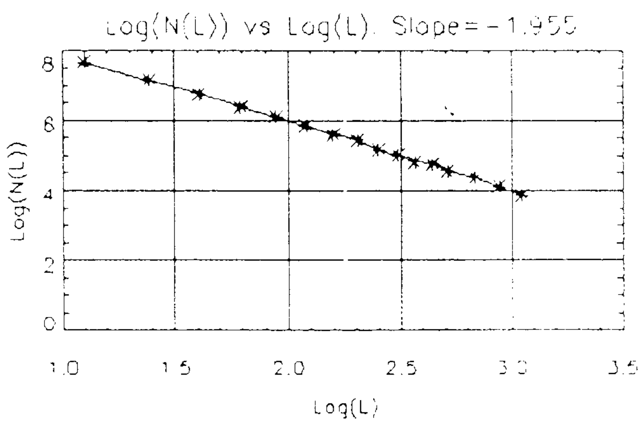
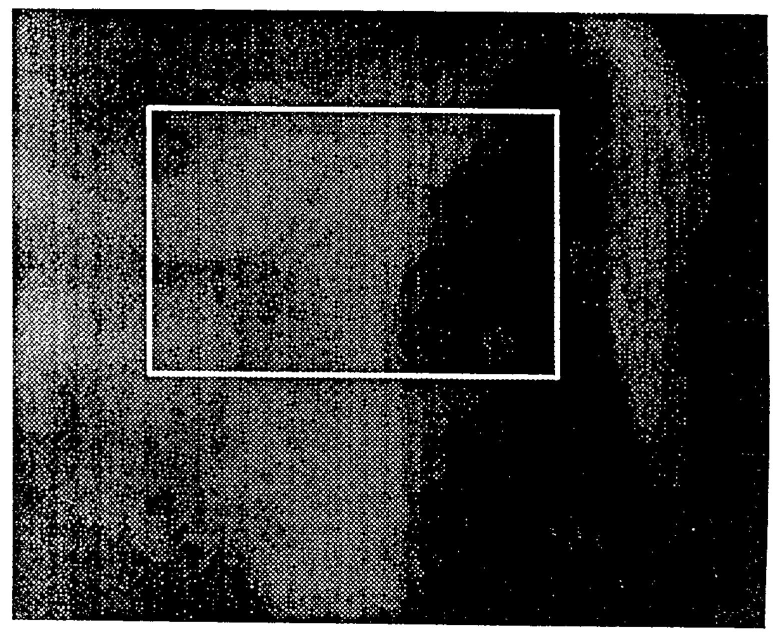


Figure D.6. Pear; FD calculated as 1.96

Analysis of the surface texture of a pepper. The surface was sharpened, edge detected and binarized. The dimension is approximately .93.



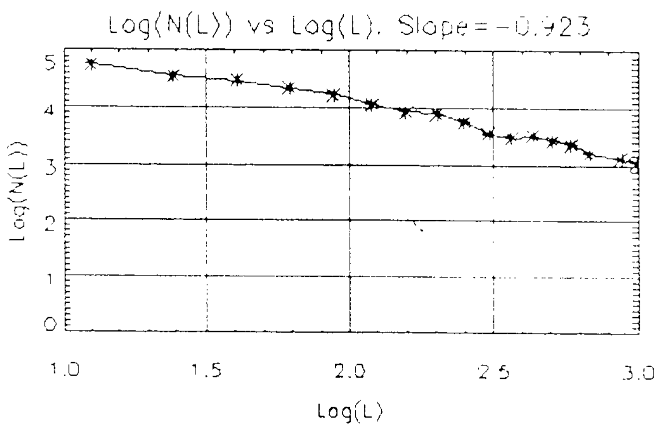
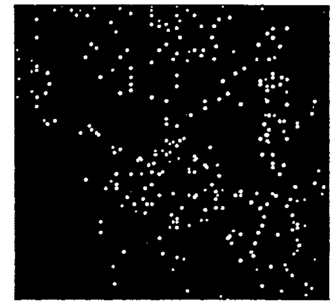
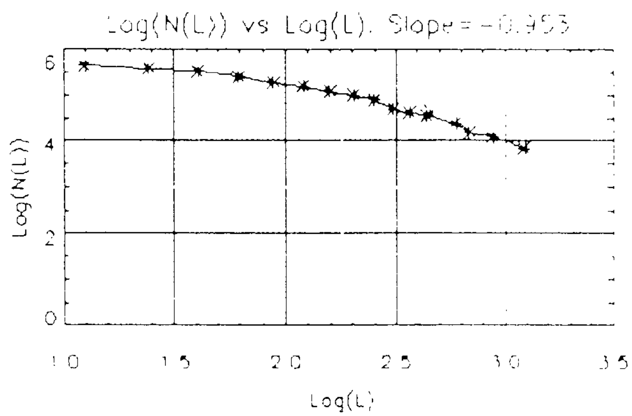


Figure D.7. Pepper; FD calculated as 0.93

Analysis of the surface texture of a banana. The surface was sharpened, edge detected and binarized. The dimension is approximately .95.





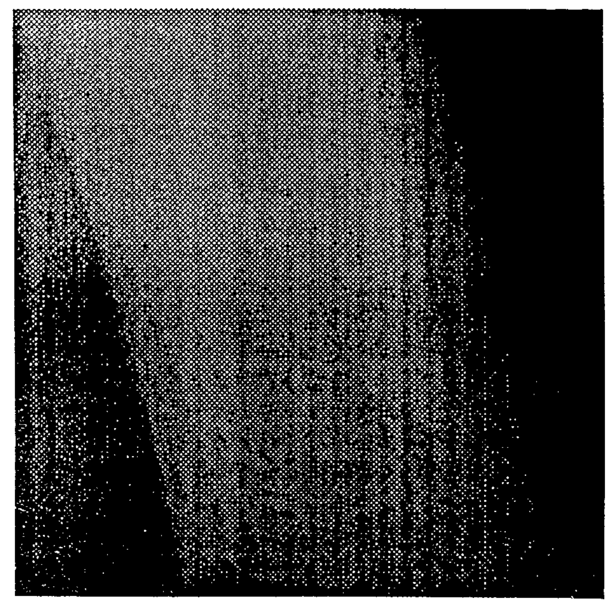
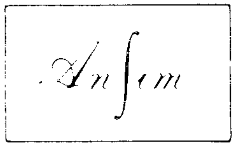
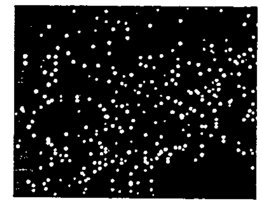
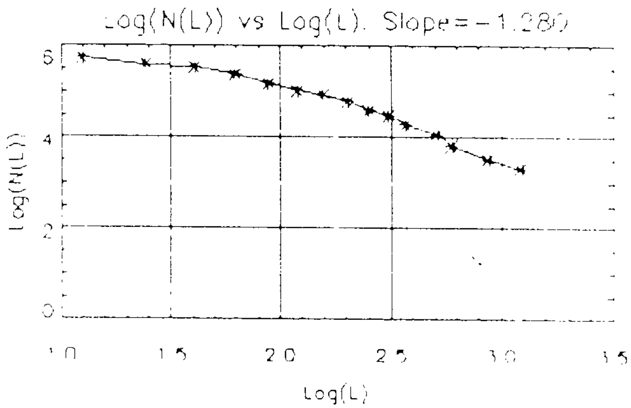


Figure D.8. Banana; FD calculated as 0.95



Analysis of the surface texture of an orange. The surface was sharpened, edge detected and binarized. The dimension is approximately 1.3.





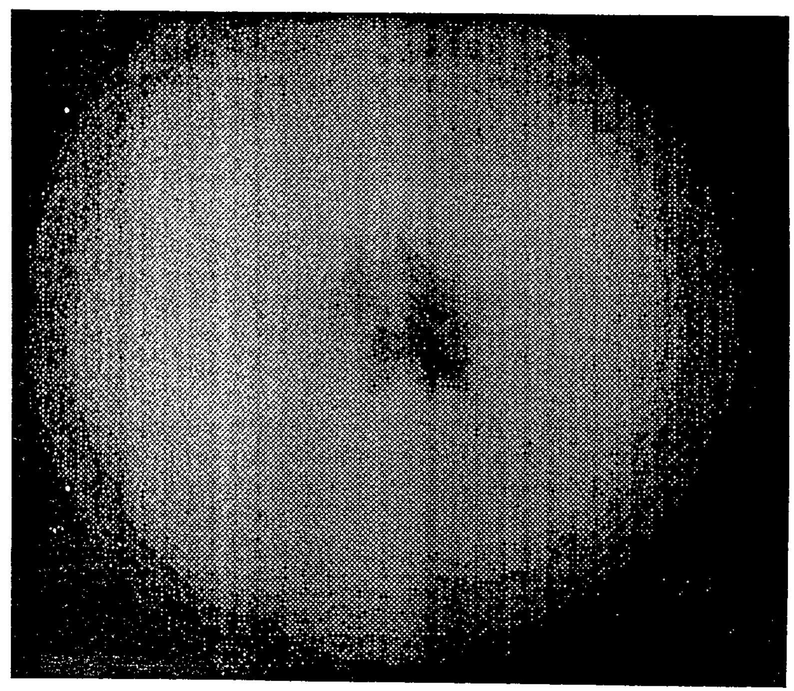
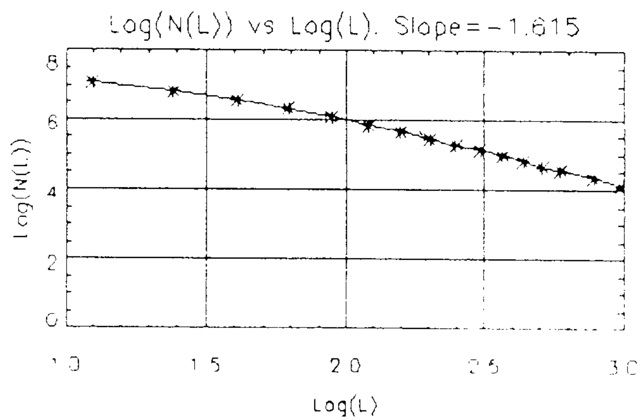
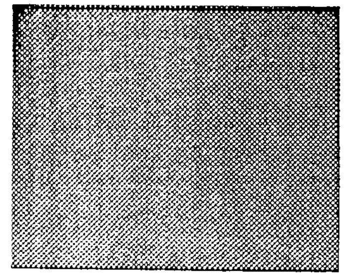
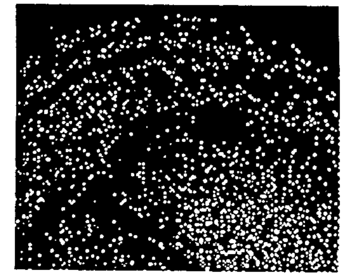


Figure D.9. Orange; FD calculated as 1.3

Analysis of the surface texture of a nectarine. The surface was sharpened, edge detected and binarized. The dimension is approximately 1.6.







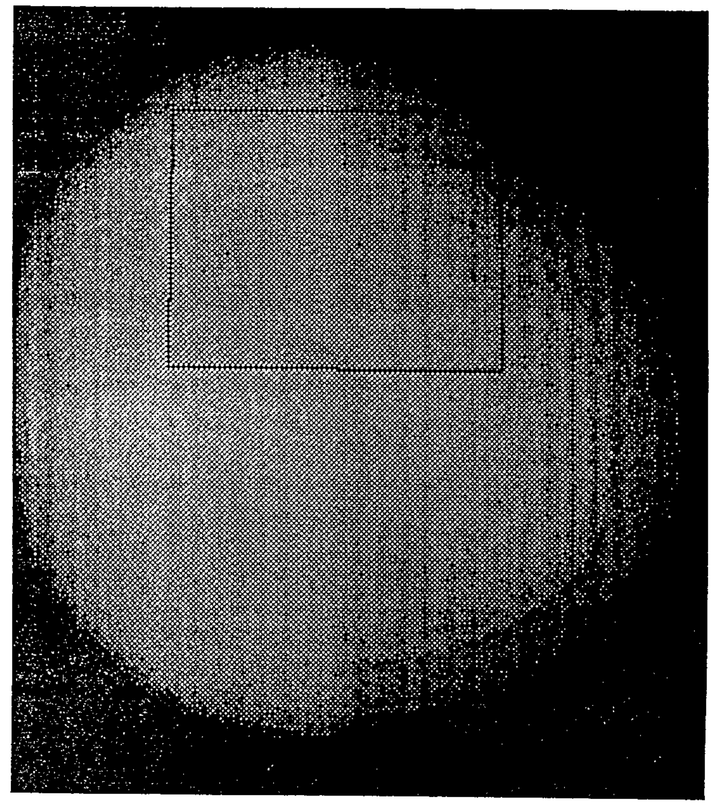
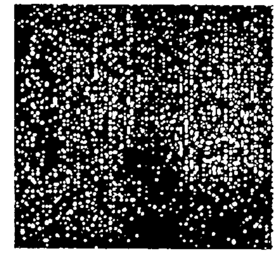
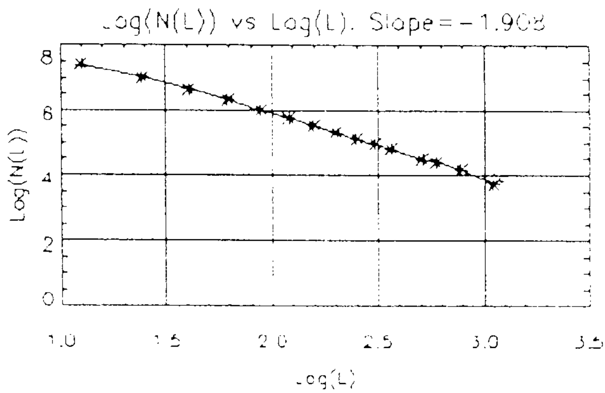


Figure D.10. Nectarine: FD calculated as 1.6

Analysis of the surface texture of an apple. The surface was sharpened, edge detected and binarized. The dimension is approximately 1.9.





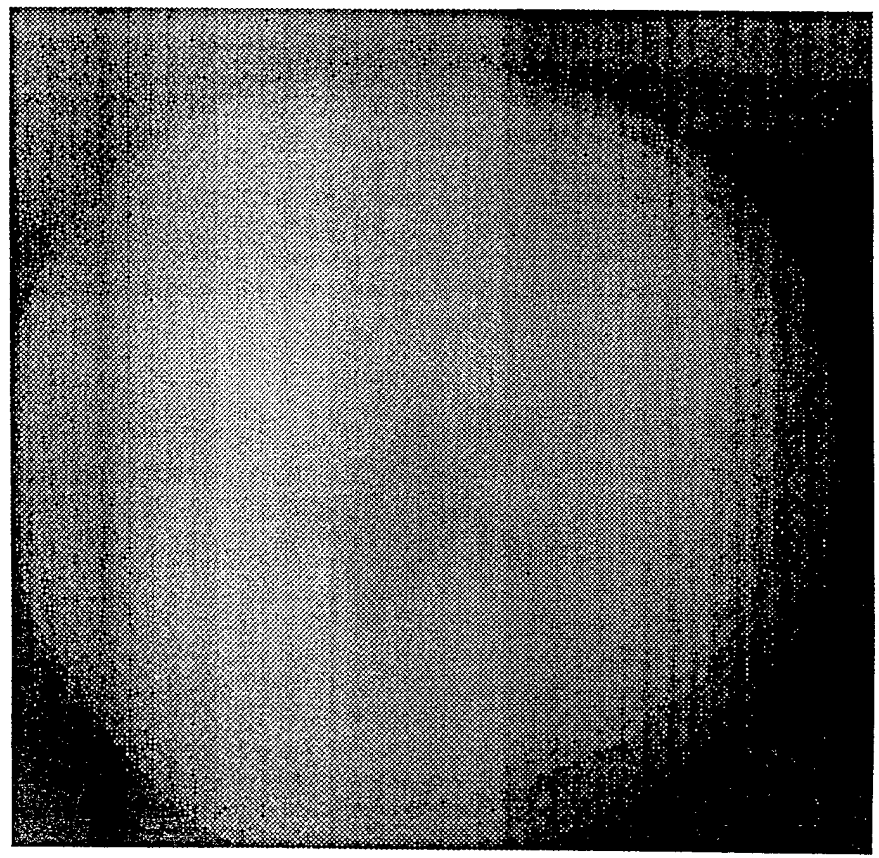
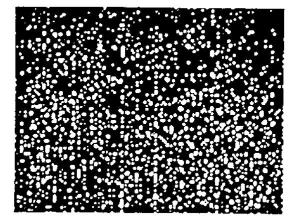
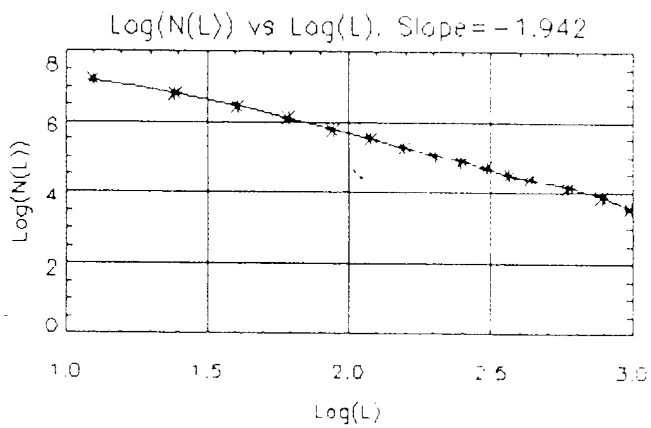


Figure D.11. Apple; FD calculated as 1.9

Analysis of the surface texture of a kiwi. The surface was sharpened, edge detected and binarized. The dimension is approximately 1.9.





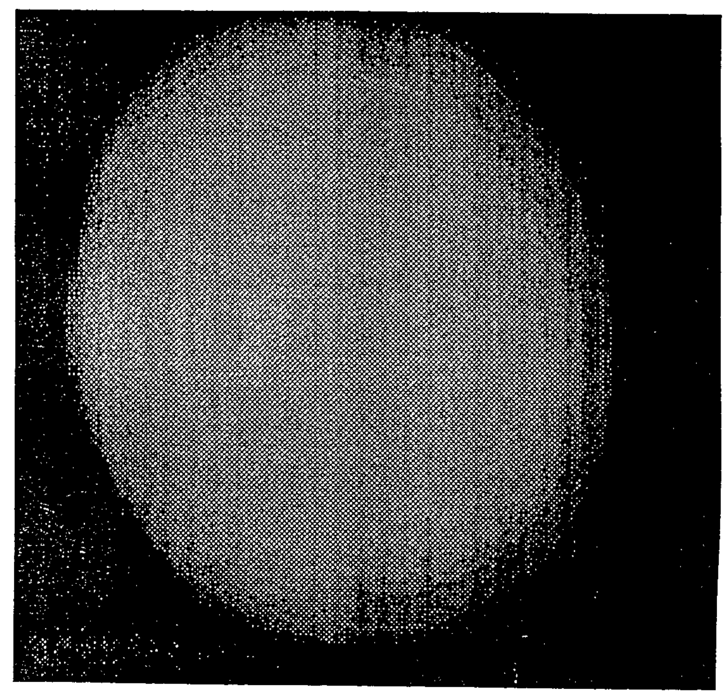


Figure D.12. Kiwi; FD calculated as 1.9

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APPENDIX E

PROCESSING OUTPUT FEATURE VECTORS AS FUNCTION OF SET NUMBER

PROCESSING OUTPUT FEATURE VECTORS FOR IMAGE SET #1 - SIDEVIEW

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pi*area fr_dim y/n
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0152_( 0.82227 0.09476 0.28200 1.35000 0.26111 4.15789 0.05469 2.54015
2.47450 0 1)
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0159_( 0.78125 0.07258 0.23600 1.73333 0.30256 3.13559 0.05078 3.26027
2.54817 0 1)
0160_( 0.62305 0.35685 0.95600 0.29091 0.54318 0.63889 0.01953 3.65671
2.51166 0 1)
0161_( 0.63477 0.05847 0.18000 1.41667 0.44118 0.49275 0.03906 2.92447
2.57424 0 1)
0161_( 0.83203 0.09677 0.01600 1.33333 0.66667 1.31915 0.10938 1.43240
0.00000 0 1)
0162_( 0.78320 0.07258 0.16600 1.81818 0.37727 2.79032 0.04688 2.75085
2.64054 0 1)
0163_( 0.81445 0.09073 0.36800 1.41667 0.22549 4.29730 0.04688 3.17213
2.39534 0 1)
0165_( 0.11328 0.42339 0.17200 1.00000 0.29758 2.60000 0.04688 2.39396
2.62949 0 1)
0166_( 0.62500 0.37097 0.90800 0.29412 0.59346 0.69444 0.01562 2.74047
2.50578 0 1)
0167_( 0.80859 0.09073 0.38000 1.40741 0.18519 4.13158 0.03516 4.32277
2.34615 0 1)
0171_( 0.77148 0.06452 0.07400 1.83333 0.56061 1.95455 0.05859 1.87241
2.76161 0 1)
0172_( 0.78320 0.07056 0.01600 1.33333 0.66667 1.25472 0.05859 1.43240
0.00000 0 1)
0172_( 0.82812 0.09677 0.03400 1.20000 0.56667 1.51852 0.07422 1.60481
2.77285 0 1)
0173_( 0.58594 0.05444 0.71600 3.00000 0.33056 0.40323 0.03516 5.55630
2.41044 0 1)
0173_( 0.77539 0.06452 0.10200 1.75000 0.45536 2.68889 0.07031 2.15178
2.68270 0 1)
0173_( 0.80664 0.46774 0.01600 1.33333 0.66667 1.05882 0.13281 1.43240
0.00000 0 1)
0177_( 0.79492 0.07661 0.11800 1.66667 0.43704 2.32877 0.04297 2.23082
2.71740 0 1)
0177_( 0.80078 0.24194 0.78200 1.21739 0.60714 0.61111 0.01562 1.87891
2.45178 0 1)
0178_( 0.62695 0.32460 0.72200 0.22222 0.55710 0.69697 0.01562 4.85456
2.54626 0 1)
0178_( 0.50000 0.31250 0.04400 0.83333 0.73333 0.64286 0.03906 1.14592
2.72624 0 1)
0179_( 0.79297 0.47177 0.11400 1.18182 0.39860 1.78218 0.05078 2.15134
2.75458 0 1)
0180_( 0.81055 0.09073 0.33400 1.52174 0.20745 4.08108 0.04297 4.01990
2.38001 0 1)
0184_( 0.62695 0.33065 0.98000 0.12500 0.61250 0.63158 0.01562 6.87102
2.52319 0 1)
0186_( 0.83984 0.10484 0.07600 1.11111 0.42222 2.59615 0.06250 1.51197
2.77105 0 1)
0188_( 0.25586 0.37903 0.64200 1.23810 0.58791 0.77273 0.01562 2.71696
2.50505 0 1)
0190_( 0.81836 0.08871 0.20200 1.47059 0.23765 3.96667 0.06250 3.45937
2.50531 0 1)
0190_( 0.79102 0.22782 0.27000 1.75000 0.53571 1.20000 0.01562 1.99758
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0190_( 0.79688 0.31250 0.12800 1.33333 0.59259 1.45455 0.02344 1.27528
2.53989 0 1)
0190_( 0.12500 0.43145 0.27200 1.26316 0.29825 2.58750 0.05078 2.08348
2.55098 0 1)
0190_( 0.17188 0.46371 0.25600 2.07692 0.36467 2.20000 0.05469 2.83129
2.60426 0 1)
0193_( 0.66602 0.28629 0.07400 1.00000 0.57812 1.54167 0.02344 1.14990
2.49367 0 1)
0195_( 0.82422 0.09476 0.22000 1.36842 0.22267 3.82857 0.05078 3.31573
2.49581 0 1)
0196_( 0.79688 0.07460 0.05600 1.33333 0.58333 2.03390 0.06641 1.37730
2.77469 0 1)
0196_( 0.62695 0.39315 0.13800 0.90909 0.62727 0.79167 0.01953 1.38124
2.54440 0 1)
0198_( 0.78906 0.07460 0.21200 1.78571 0.30286 3.52083 0.05078 3.55257
2.54384 0 1)
0199_( 0.80859 0.08871 0.29800 1.52381 0.22173 4.06977 0.03516 3.67260
2.43380 0 1)
0199_( 0.71484 0.42137 0.16400 1.20000 0.68333 1.73529 0.02344 1.05476
2.49764 0 1)
0201_( 0.82422 0.09476 0.21600 1.36842 0.21862 3.72222 0.04297 3.43007
2.48337 0 1)
0201_( 0.70703 0.45766 0.02800 1.25000 0.70000 0.65854 0.03906 1.28916
2.71842 0 1)
0202_( 0.62500 0.37097 0.68000 0.34884 0.52713 0.67568 0.01953 3.64708
2.54573 0 1)
0203_( 0.62109 0.09879 0.99600 0.43860 0.34947 0.73585 0.02344 6.02717
2.26588 0 1)
0204_( 0.82617 0.09274 0.02000 1.00000 0.62500 1.54945 0.10547 1.29977
2.80054 0 1)
0208_( 0.62500 0.35282 0.70200 0.28261 0.58696 0.63636 0.01562 3.17042
2.52640 0 1)
0209_( 0.64258 0.05444 0.20400 3.71429 0.56044 0.58537 0.04297 4.56190
2.75125 0 1)
0210_( 0.31836 0.09073 0.84400 0.37500 0.48843 0.60377 0.02734 4.02652
2.33776 0 1)
0210_( 0.81250 0.09274 0.38800 1.44000 0.21556 3.92308 0.04688 3.50470
2.37099 0 1)
0212_( 0.77734 0.06855 0.19000 1.76923 0.31773 3.36735 0.04688 3.43645
2.58551 0 1)
0212_( 0.77930 0.23185 0.20400 1.70000 0.60000 1.25000 0.01562 2.05361
2.48759 0 1)
0216_( 0.82031 0.09476 0.30600 1.27273 0.24838 4.00000 0.04297 2.81788
2.43014 0 1)
0217_( 0.81250 0.09073 0.34000 1.36000 0.20000 3.97368 0.03906 4.05202
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0217_( 0.75781 0.30645 0.25400 0.93750 0.52917 1.20000 0.01562 1.65147
2.49890 0 1)
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2.77341 0 1)
0223_( 0.83008 0.09476 0.01600 1.33333 0.66667 1.31944 0.12891 1.43240
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0223_( 0.24414 0.12500 0.53400 1.23529 0.74790 4.35294 0.02344 0.95825
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0223_( 0.16016 0.19758 0.71400 1.23810 0.65385 1.55172 0.01953 0.92956
2.56154 0 1)
0223_( 0.24219 0.19556 0.53600 1.11111 0.74444 3.95652 0.02734 0.91259
2.61542 0 1)
0223_( 0.16016 0.26613 0.59800 1.21053 0.68421 1.72973 0.01953 0.98657
2.55704 0 1)
0223_( 0.24219 0.26613 0.52600 1.17647 0.77353 3.53333 0.02734 1.01980
2.61933 0 1)
0223_( 0.76172 0.30444 0.76200 1.13636 0.69273 0.71429 0.01562 1.46282
2.47413 0 1)
0223_( 0.15625 0.33669 0.37200 1.33333 0.62000 1.73810 0.01953 2.46690
2.53045 0 1)
0223_( 0.24023 0.33468 0.45800 1.25000 0.71562 3.68750 0.01953 1.16282
2.58660 0 1)
0223_( 0.15430 0.40927 0.30000 1.20000 0.55556 1.46753 0.01953 1.15749
2.50752 0 1)
0223_( 0.23828 0.40927 0.39000 1.42857 0.69643 2.73077 0.01953 1.24726
2.58023 0 1)
0223_( 0.20508 0.47984 0.01000 1.00000 0.55556 1.15714 0.06250 1.27324
0.00000 0 1)
0224_( 0.78320 0.06653 0.01000 1.00000 0.55556 1.82500 0.05859 1.27324
0.00000 0 1)
0224_( 0.83594 0.10282 0.03600 1.20000 0.60000 2.00000 0.06641 1.37555
2.78426 0 1)
0224_( 0.71484 0.12702 0.47600 1.25000 0.74375 8.58333 0.01953 0.96498
2.58893 0 1)
0224_( 0.71875 0.19758 0.46000 1.31250 0.68452 7.46154 0.02344 1.05561
2.62096 0 1)
0224_( 0.80469 0.19758 0.62000 1.27778 0.74879 2.89474 0.02344 1.02193
2.58090 0 1)
0224_( 0.72070 0.26613 0.48800 1.16667 0.64550 5.27778 0.01953 0.93544
2.62800 0 1)
0224_( 0.80469 0.26613 0.65200 1.33333 0.75463 2.00000 0.01953 0.99888
2.53333 0 1)
0224_( 0.49805 0.31250 0.07600 0.87500 0.67857 0.50000 0.02734 1.09514
2.67331 0 1)
0224_( 0.72070 0.33669 0.54200 1.17647 0.79706 4.19048 0.02344 0.98255
2.60310 0 1)
0224_( 0.80859 0.33468 0.67600 1.25000 0.67600 1.48485 0.01562 0.99287
2.52980 0 1)
0224_( 0.72266 0.40927 0.51600 1.23529 0.72269 2.45946 0.02344 1.04455
2.60921 0 1)
0224_( 0.77930 0.47984 0.01600 1.33333 0.66667 1.07273 0.07812 1.43240
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0.00000 0 1)
0224_( 0.63867 0.47984 0.42400 5.12500 0.64634 0.86792 0.03906 4.24969
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0225_( 0.78711 0.07258 0.17600 1.83333 0.33333 3.00000 0.04297 3.05163
2.56674 0 1)
0225_( 0.83008 0.10081 0.20000 1.20000 0.37037 3.00000 0.04688 1.61145
2.63193 0 1)
0226_( 0.50000 0.31250 0.05000 1.00000 0.69444 0.58824 0.03125 1.12072
2.70634 0 1)
0230_( 0.82031 0.09476 0.29000 1.33333 0.24660 3.80000 0.03906 2.80399
2.46240 0 1)
0233_( 0.81445 0.09274 0.36600 1.39130 0.24864 3.72727 0.04688 2.84928
2.40869 0 1)
0233_( 0.50000 0.31250 0.04000 0.83333 0.66667 0.54717 0.04297 1.06988
2.73351 0 1)
0235_( 0.80078 0.08065 0.30000 1.69565 0.16722 4.62963 0.05859 6.21135
2.35859 0 1)
0238_( 0.50000 0.31250 0.04400 0.83333 0.73333 0.57407 0.03125 1.14592
2.71112 0 1)
0239_( 0.59961 0.05444 0.62200 2.89474 0.29761 0.49275 0.03906 6.54323
2.41115 0 1)
0239_( 0.81250 0.09073 0.41200 1.46154 0.20850 4.71875 0.04297 3.53569
2.35165 0 1)
0239_( 0.62500 0.30847 0.47400 0.33333 0.54861 1.25714 0.01562 3.45212
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0240_( 0.79102 0.07460 0.14800 1.72727 0.35407 2.87719 0.04297 2.71401
2.65018 0 1)
0242_( 0.78906 0.07258 0.16400 1.66667 0.34167 3.12727 0.04688 2.61159
2.60521 0 1)
0242_( 0.82617 0.09879 0.24800 1.29412 0.33155 3.43478 0.05078 1.81653
2.55988 0 1)
0243_( 0.82812 0.09879 0.24000 1.23529 0.33613 3.18000 0.03906 1.91089
2.58561 0 1)
0244_( 0.81836 0.08669 0.13800 1.46154 0.27935 3.08108 0.05469 3.12523
2.57955 0 1)
0244_( 0.50000 0.31250 0.04200 1.00000 0.58333 0.54167 0.03125 0.96289
2.70775 0 1)
0244_( 0.11914 0.41935 0.38000 0.86207 0.26207 3.03448 0.04297 2.90426
2.47454 0 1)
0246_( 0.77148 0.06452 0.07800 1.83333 0.59091 2.00000 0.05469 1.94965
2.75359 0 1)
0246_( 0.33398 0.21169 0.42600 0.28205 0.49650 1.34286 0.02344 4.35271
2.55917 0 1)
0247_( 0.84180 0.43347 0.33400 0.96429 0.22090 2.77966 0.03906 3.03695
2.64812 0 1)
0249_( 0.50000 0.31452 0.05400 0.71429 0.77143 0.61404 0.04297 1.19978
2.74277 0 1)
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PROCESSING OUTPUT FEATURE VECTORS FOR IMAGE SET #2 - SIDEVIEW

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0251_( 0.78516 0.07258 0.19800 1.92308 0.30462 3.26000 0.04297 3.59503
2.57842 0 1)
0252_( 0.78516 0.07056 0.18000 1.91667 0.32609 3.40385 0.05078 3.34918
2.57511 0 1)
0253_( 0.78320 0.07056 0.21600 1.71429 0.32143 3.21818 0.05078 3.05578
2.53978 0 1)
0253_( 0.33008 0.46371 0.09800 0.50000 0.68056 0.75806 0.02734 2.07233
2.68434 0 1)
0255_( 0.50000 0.31250 0.04400 0.83333 0.73333 0.50000 0.03516 1.14592
2.71665 0 1)
0256_( 0.81641 0.09476 0.38800 1.37037 0.19419 4.67742 0.04297 3.76154
2.37677 0 1)
0259_( 0.83008 0.09879 0.17000 1.20000 0.31481 4.03125 0.05078 2.10474
2.62115 0 1)
0259_( 0.69727 0.41331 0.08600 1.00000 0.67188 1.90909 0.02344 1.03132
2.49565 0 1)
0261_( 0.50000 0.31452 0.05200 0.85714 0.61905 0.54348 0.03516 1.03451
2.70244 0 1)
0261_( 0.62891 0.36492 0.68200 0.29545 0.59615 0.66667 0.01562 2.91946
2.47818 0 1)
0262_( 0.82422 0.44960 0.30600 1.42857 0.24286 2.75000 0.04297 2.94691
2.68940 0 1)
0264_( 0.82031 0.09274 0.23200 1.33333 0.19728 4.56667 0.04297 3.94626
2.44952 0 1)
0266_( 0.50000 0.31452 0.04600 1.00000 0.63889 0.62264 0.03125 1.04174
2.69659 0 1)
0267_( 0.82422 0.09476 0.22600 1.30000 0.21731 3.52778 0.03906 3.33841
2.46464 0 1)
0267_( 0.50000 0.31250 0.04400 0.83333 0.73333 0.55769 0.03906 1.14592
2.74396 0 1)
0268_( 0.82812 0.09879 0.20600 1.26316 0.22588 3.96970 0.04688 3.33358
2.52247 0 1)
0269_( 0.82422 0.09274 0.11400 1.36364 0.34545 3.00000 0.06641 2.39017
2.68555 0 1)
0270_( 0.84180 0.43347 0.37400 0.96667 0.21494 2.94444 0.03906 2.86479
2.63467 0 1)
0271_( 0.82031 0.09476 0.31600 1.33333 0.26871 3.94737 0.04688 2.44662
2.45689 0 1)
0273_( 0.08789 0.24395 0.44800 0.18605 0.65116 0.78652 0.04688 4.95475
2.69825 0 1)
0278_( 0.16211 0.25605 0.62800 1.25000 0.62800 1.35556 0.01953 1.30380
2.51971 0 1)
0279_( 0.50000 0.31452 0.06400 0.85714 0.76190 0.67442 0.03516 1.27324
2.67386 0 1)
0280_( 0.83203 0.09677 0.01600 1.33333 0.66667 1.30303 0.09766 1.43240
0.00000 0 1)
0281_( 0.78320 0.29234 0.17000 1.55556 0.67460 1.28571 0.01953 1.30218
2.49971 0 1)
0282_( 0.21875 0.18347 0.08800 1.42857 0.62857 1.50000 0.02344 1.75071
2.53450 0 1)
0283_( 0.83984 0.10282 0.01600 1.33333 0.66667 1.34375 0.10938 1.43240
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2.43493 0 1)
0284_( 0.61523 0.17540 0.92800 0.47826 0.45850 0.73529 0.01562 4.81395
2.44849 0 1)
0285_( 0.83008 0.09677 0.15600 1.28571 0.30952 3.15789 0.04297 2.26703
2.59920 0 1)
0285_( 0.81055 0.27621 0.53600 1.23810 0.49084 1.35294 0.01562 1.54070
2.46790 0 1)
0285_( 0.50000 0.31250 0.05200 0.83333 0.86667 0.67347 0.03125 1.29977
2.70192 0 1)
0286_( 0.32031 0.08065 0.56400 0.77500 0.22742 1.18367 0.03516 6.91348
2.25418 0 1)
0286_( 0.80859 0.34677 0.08200 1.00000 0.64062 1.40000 0.02344 1.12101
2.54233 0 1)
0288_( 0.61719 0.47984 0.26000 1.75000 0.51587 0.97000 0.03906 2.00460
2.54254 0 1)
0289_( 0.77148 0.34879 0.11600 1.11111 0.64444 1.48387 0.02344 1.06988
2.57792 0 1)
0290_( 0.83789 0.10282 0.11400 1.18182 0.39860 2.65385 0.05078 1.73530
2.72357 0 1)
0291_( 0.82617 0.09274 0.09200 1.44444 0.39316 2.95556 0.06250 2.36838
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0294_( 0.75195 0.26008 0.34000 0.78947 0.59649 2.25000 0.01953 1.22272
2.59733 0 1)
0295_( 0.77344 0.06452 0.12800 1.60000 0.40000 2.84127 0.05859 2.31739
2.65340 0 1)
0296_( 0.79883 0.07661 0.03600 1.20000 0.60000 1.81690 0.04688 1.37555
2.75413 0 1)
0296_( 0.50000 0.31250 0.06200 0.75000 0.64583 0.64286 0.03906 1.35812
2.66466 0 1)
0297_( 0.16797 0.27016 0.53000 1.62500 0.63702 1.43750 0.01953 1.80416
2.55546 0 1)
0297_( 0.82422 0.44758 0.28800 1.45000 0.24828 2.63514 0.04688 2.97181
2.70548 0 1)
0301_( 0.81250 0.09073 0.33000 1.47826 0.21100 4.46154 0.05078 3.79347
2.41044 0 1)
0302_( 0.62500 0.37298 0.71000 0.41026 0.56891 0.63333 0.01562 3.19595
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0302_( 0.50000 0.31250 0.04400 0.83333 0.73333 0.58491 0.03516 1.14592
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0303_( 0.63281 0.05847 0.17200 1.45455 0.48864 0.53521 0.04297 3.19034
2.57350 0 1)
0307_( 0.61719 0.05040 0.28400 3.40000 0.41765 0.54386 0.04297 4.76298
2.65623 0 1)
0307_( 0.78906 0.07460 0.22000 1.66667 0.29333 3.24074 0.03906 3.50816
2.56141 0 1)
0308_( 0.50000 0.31250 0.05000 1.00000 0.69444 0.60656 0.03516 1.12072
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0311_( 0.34180 0.36694 0.85800 0.41463 0.61549 0.76667 0.01562 2.64834
2.49508 0 1)
0312_( 0.16406 0.25403 0.85800 1.07692 0.58929 1.47826 0.01562 1.54202
2.53096 0 1)
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0315_( 0.83203 0.44355 0.28400 1.29167 0.19086 3.21667 0.05078 3.99802
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0316_( 0.81445 0.09073 0.32200 1.52381 0.23958 4.17949 0.05859 3.22289
2.42410 0 1)
0316_( 0.08789 0.27823 0.71800 0.14286 0.42385 0.94444 0.04688 10.05900
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0318_( 0.81836 0.09073 0.26800 1.40909 0.19648 4.88889 0.05078 4.05627
2.41795 0 1)
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2.51057 0 1)
0319_( 0.08398 0.22782 0.29600 0.14286 0.58730 0.84821 0.05469 8.43399
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0320_( 0.50000 0.31250 0.04800 0.83333 0.80000 0.55357 0.03906 1.22260
2.74218 0 1)
0321_( 0.81055 0.08871 0.33800 1.50000 0.19560 4.50000 0.03906 4.09337
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0322_( 0.81055 0.08871 0.31000 1.42857 0.24603 3.87805 0.05078 3.15009
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0323_( 0.20898 0.26411 0.75600 0.47500 0.49737 2.14706 0.01562 2.53776
2.48119 0 1)
0326_( 0.80664 0.08468 0.36800 1.60714 0.14603 3.93750 0.05859 6.63509
2.30411 0 1)
0326_( 0.50000 0.31250 0.05200 0.83333 0.86667 0.63830 0.03516 1.29977
2.68182 0 1)
0328_( 0.82422 0.09476 0.04000 1.20000 0.66667 1.66667 0.06250 1.43240
2.78896 0 1)
0329_( 0.32812 0.06653 0.08800 0.88889 0.61111 1.57143 0.01953 1.52581
2.52364 0 1)
0329_( 0.80273 0.08266 0.26600 1.52381 0.19792 4.23333 0.05469 4.72391
2.42320 0 1)
0332_( 0.82227 0.09073 0.13000 1.25000 0.36111 2.84783 0.06250 2.04628
2.65714 0 1)
0332_( 0.50000 0.31250 0.04000 0.83333 0.66667 0.61818 0.03516 1.06988
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0335_( 0.82422 0.09476 0.21200 1.31579 0.22316 4.26667 0.05078 3.76329
2.50333 0 1)
0336_( 0.62695 0.47782 0.06000 1.16667 0.71429 1.18824 0.03906 1.19366
2.42494 0 1)
0337_( 0.50000 0.31452 0.07000 0.75000 0.72917 0.71698 0.03516 1.07220
2.67761 0 1)
0339_( 0.78125 0.06855 0.07400 1.42857 0.52857 2.25926 0.07422 1.87241
2.76937 0 1)
0339_( 0.77344 0.29234 0.72000 1.15625 0.30405 2.14815 0.02344 2.51322
2.38107 0 1)
0339_( 0.84180 0.44355 0.02800 1.00000 0.56000 1.35659 0.09375 1.28916
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0344_( 0.80273 0.08065 0.25600 1.65000 0.19394 4.12903 0.05469 5.09296
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2.77145 0 1)
0349_( 0.50000 0.31250 0.05400 1.00000 0.75000 0.52083 0.03906 1.19978
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0350_( 0.78320 0.06653 0.01000 1.00000 0.55556 1.61039 0.07422 1.27324
0.00000 0 1)
0350_( 0.82812 0.09677 0.04000 0.85714 0.47619 2.12698 0.07031 1.43240
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0351_( 0.75000 0.05645 0.12000 1.87500 0.50000 2.35366 0.06641 2.38733
2.67144 0 1)
0353_( 0.77344 0.06452 0.06400 1.50000 0.59259 2.03750 0.06250 1.53319
2.76403 0 1)
0353_( 0.81836 0.09274 0.28000 1.47368 0.26316 3.92308 0.03906 2.97089
2.47740 0 1)
0354_( 0.83203 0.44355 0.38000 1.14815 0.22700 2.98182 0.03906 3.13115
2.64464 0 1)
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2.51680 0 1)
0356_( 0.80859 0.46169 0.32800 1.47619 0.25192 2.37037 0.04297 3.12716
2.68351 0 1)
0357_( 0.81055 0.31855 0.09600 1.83333 0.72727 1.33333 0.01953 1.48137
2.39371 0 1)
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2.46281 0 1)
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0366_( 0.62500 0.36089 0.66000 0.27907 0.63953 0.64286 0.01562 3.29424
2.50765 0 1)
0366_( 0.50000 0.31250 0.04400 0.83333 0.73333 0.56863 0.04297 1.14592
2.73300 0 1)
0367_( 0.83594 0.10081 0.02400 0.80000 0.60000 1.76000 0.07031 1.27324
2.78384 0 1)
0367_( 0.62305 0.12097 0.53200 0.29268 0.54065 1.15385 0.01562 3.97842
2.54247 0 1)
0368_( 0.76758 0.06250 0.16000 1.90000 0.42105 2.79412 0.05469 2.53353
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0369_( 0.61133 0.04839 0.20800 2.27273 0.37818 0.48039 0.04297 3.68415
2.64202 0 1)
0373_( 0.78320 0.07258 0.25000 1.87500 0.26042 3.34615 0.03906 4.19711
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0374_( 0.77539 0.23387 0.09200 1.66667 0.76667 2.00000 0.01953 1.40375
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0374_( 0.76367 0.30040 0.21800 1.14286 0.48661 1.84615 0.02344 1.51308
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0374_( 0.83008 0.31250 0.09600 1.12500 0.66667 1.56757 0.02344 1.29977
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0375_( 0.82812 0.23589 0.15400 2.00000 0.60156 1.30000 0.02344 1.66248
2.50233 0 1)
0376_( 0.81055 0.08669 0.35200 1.50000 0.17357 3.88571 0.05078 4.94030
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0376_( 0.74805 0.27016 0.28400 0.47619 0.67619 1.78378 0.01562 1.48625
2.50546 0 1)
0376_( 0.62305 0.36290 0.78200 0.42500 0.57500 0.67647 0.01953 2.67103
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0376_( 0.84180 0.30242 0.26400 1.13333 0.51765 1.57692 0.01953 1.38396
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0382_( 0.80469 0.08468 0.40400 1.56667 0.14326 3.76471 0.04688 6.51062
2.29284 0 1)
0382_( 0.75195 0.25605 0.08800 0.70000 0.62857 1.86207 0.01953 1.32629
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0382_( 0.50000 0.31250 0.04400 0.83333 0.73333 0.51111 0.03125 1.14592
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0386_(0.83203 0.10081 0.20800 1.26667 0.36491 3.58537 0.05469 1.62599
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0389_(0.82422 0.09274 0.09200 1.10000 0.41818 2.69388 0.05859 1.83028
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0390_(0.85938 0.27218 0.12000 1.00000 0.60000 1.27907 0.02344 1.01357
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0390_(0.75195 0.29234 0.14800 1.33333 0.68519 1.30303 0.02344 1.23430
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0391_(0.76758 0.30242 0.09000 1.12500 0.62500 1.35714 0.01953 1.27324
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0393_(0.82422 0.09476 0.21200 1.36842 0.21457 3.78378 0.04297 3.55257
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0394_(0.83398 0.09879 0.05200 0.85714 0.61905 1.93939 0.07031 1.29977
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0395_(0.83008 0.44758 0.22600 1.31579 0.23789 2.87324 0.05078 2.82072
2.72950 0 1)
0397_(0.81250 0.08871 0.34800 1.45833 0.20714 4.51429 0.03906 3.89466
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0398_(0.85156 0.29435 0.09600 1.12500 0.66667 1.27907 0.01953 1.29977
2.44517 0 1)
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0400_(0.82812 0.44758 0.32400 1.34783 0.22721 2.82540 0.03906 2.93176
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0405_(0.09180 0.22782 0.02600 0.80000 0.65000 0.79730 0.03906 1.61145
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0410_( 0.50000 0.31452 0.05400 0.71429 0.77143 0.56818 0.03906 1.19978
2.73601 0 1)
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0415_( 0.82031 0.09476 0.29000 1.35000 0.26852 3.35417 0.03906 2.67469
2.46727 0 1)
0416_( 0.81445 0.08669 0.18600 1.31250 0.27679 3.45000 0.06250 2.94278
2.54162 0 1)
0418_( 0.61523 0.04839 0.25000 2.50000 0.34722 0.42718 0.03906 4.40737
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0419_( 0.78906 0.07460 0.26000 1.70588 0.26369 3.85366 0.05078 3.90154
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0420_( 0.78320 0.07258 0.19800 1.84615 0.31731 2.77612 0.04297 3.38052
2.58706 0 1)
0420_( 0.33203 0.47177 0.13200 0.61538 0.63462 0.54795 0.02734 1.34486
2.64589 0 1)
0421_( 0.62695 0.36290 0.62000 0.32500 0.59615 0.66667 0.01562 2.55532
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0421_( 0.80469 0.35685 0.13800 0.75000 0.63889 1.21622 0.01953 1.52168
2.52918 0 1)
0422_( 0.32617 0.09879 0.77800 1.41667 0.47672 1.22727 0.01562 4.70984
2.52051 0 1)
0422_( 0.83008 0.10081 0.18400 1.26667 0.32281 3.27660 0.03516 2.12796
2.63147 0 1)
0423_( 0.79297 0.07661 0.21200 1.68750 0.24537 3.61702 0.03516 4.21761
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0424_( 0.82617 0.09476 0.03200 1.00000 0.64000 1.57471 0.06641 1.32629
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0425_( 0.17969 0.39516 0.07600 1.00000 0.77551 0.82979 0.02344 1.28916
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0426_( 0.50000 0.31452 0.06000 0.85714 0.71429 0.64706 0.03516 1.19366
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0427_( 0.50000 0.31452 0.05000 0.71429 0.71429 0.58000 0.04297 1.41793
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0427_( 0.62695 0.37500 0.77200 0.24074 0.54986 0.62857 0.01562 4.39658
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0429_( 0.79883 0.10282 0.89400 1.68293 0.15801 1.58537 0.03516 5.63546
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0433_( 0.82031 0.09274 0.27600 1.34783 0.19355 4.40625 0.04688 4.21124
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0434_( 0.85742 0.28226 0.14200 0.90909 0.64545 1.33333 0.02344 1.19543
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0434_( 0.83203 0.44153 0.35200 1.40909 0.25806 2.96610 0.04297 2.57485
2.67815 0 1)
0435_( 0.33398 0.10484 0.11000 0.50000 0.76389 1.36364 0.01953 1.65787
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0435_( 0.52930 0.14315 0.13400 1.20000 0.55833 1.26471 0.02344 1.31206
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0439_( 0.82617 0.09677 0.20600 1.29412 0.27540 3.41026 0.03906 2.61122
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0439_( 0.50000 0.31452 0.06600 0.85714 0.78571 0.67442 0.03906 1.19834
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0447_( 0.46484 0.32258 0.02000 1.00000 0.62500 0.74545 0.04688 1.29977
2.65798 0 1)
0450_( 0.83008 0.09476 0.01600 1.33333 0.66667 1.31250 0.07812 1.43240
0.00000 0 1)
0451_( 0.83789 0.30040 0.15400 1.00000 0.53472 1.21429 0.01562 1.27324
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0455_( 0.83398 0.09879 0.01600 1.33333 0.66667 1.40385 0.08984 1.43240
0.00000 0 1)
0457_( 0.82422 0.09476 0.24000 1.36842 0.24291 3.94118 0.04688 3.16438
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0457_( 0.08398 0.23992 0.11200 0.40000 0.62222 0.73451 0.05469 2.47869
2.78650 0 1)
0457_( 0.62500 0.37500 0.65400 0.40541 0.58919 0.53333 0.01562 2.12239
2.53650 0 1)
0458_( 0.82617 0.44960 0.30200 1.32000 0.18303 3.07692 0.05078 3.90948
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0459_( 0.82031 0.09476 0.32400 1.27273 0.26299 4.00000 0.05078 2.57403
2.44501 0 1)
0460_( 0.42969 0.39315 0.19400 0.68750 0.55114 1.10638 0.01953 2.08685
2.55498 0 1)
0461_( 0.84375 0.24395 0.15600 1.30000 0.60000 1.37143 0.01953 1.24778
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0464_( 0.62305 0.47782 0.11800 1.44444 0.50427 1.07447 0.03906 1.63013
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0465_( 0.64062 0.27419 0.14200 1.20000 0.59167 1.52174 0.01562 1.31846
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0468_( 0.50000 0.31452 0.06600 0.75000 0.68750 0.69565 0.03516 1.19834
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0469_( 0.80859 0.08468 0.20200 1.41176 0.24755 3.50000 0.05469 3.67434
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0475_( 0.62305 0.27218 0.73000 0.24528 0.52975 0.82759 0.01562 4.20965
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0477_( 0.77930 0.31855 0.31000 1.00000 0.53633 1.20000 0.01562 1.99020
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0478_( 0.84180 0.10282 0.02000 1.00000 0.62500 1.55000 0.11719 1.29977
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0481_( 0.82422 0.09476 0.23000 1.26316 0.25219 3.85294 0.05078 2.89493
2.50436 0 1)
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2.70686 0 1)
0482_( 0.83008 0.44556 0.32400 1.18182 0.28322 2.70312 0.04297 2.24974
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0483_( 0.78516 0.07258 0.16600 1.90909 0.35931 2.73016 0.04297 2.96102
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0484_( 0.81641 0.09274 0.32400 1.40909 0.23754 3.78571 0.03906 3.05896
2.42365 0 1)
0487_( 0.81836 0.09073 0.29800 1.43478 0.19631 4.32258 0.05078 4.00256
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0488_( 0.80664 0.46774 0.01600 1.33333 0.66667 1.08947 0.15234 1.43240
0.00000 0 1)
0489_( 0.49805 0.31452 0.04800 0.71429 0.68571 0.60000 0.04688 1.22260
2.74383 0 1)
0490_( 0.77539 0.06653 0.16600 2.10000 0.39524 2.81667 0.05078 2.96102
2.61337 0 1)
0491_( 0.83984 0.10484 0.07600 1.25000 0.47500 2.34545 0.04297 1.28916
2.77078 0 1)
0492_( 0.82617 0.09476 0.23600 1.35000 0.21852 4.21875 0.05469 3.43897
2.46692 0 1)
0493_( 0.62500 0.37702 0.65800 0.27907 0.63760 0.66667 0.01562 2.91638
2.53734 0 1)
0496_( 0.62109 0.05444 0.18800 1.72727 0.44976 0.53409 0.03906 3.28866
2.61912 0 1)
0496_( 0.32422 0.17339 0.22600 0.68421 0.45749 1.20000 0.01562 1.97711
2.53554 0 1)
0498_( 0.82227 0.09476 0.26200 1.31579 0.27579 3.51111 0.03906 2.58726
2.51366 0 1)
0500_( 0.61914 0.06048 0.08200 1.14286 0.73214 0.71875 0.01953 1.12101
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2.53765 0 1)
0500_( 0.80664 0.46371 0.28000 1.36842 0.28340 2.27160 0.04297 2.83202
2.70641 0 1)
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PROCESSING OUTPUT FEATURE VECTORS FOR IMAGE SET #3 - SIDEVIEW

0501_(0.77148 0.06653 0.18000 1.69231 0.31469 3.05000 0.05078 3.34918
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0504_(0.78320 0.07056 0.15200 1.63636 0.38384 2.81818 0.05469 2.57831
2.65891 0 1)
0504_(0.82617 0.09677 0.25000 1.21053 0.28604 3.59574 0.04688 2.38113
2.53378 0 1)
0505_(0.82617 0.09677 0.26600 1.28571 0.23457 3.79412 0.05078 2.93732
2.48107 0 1)
0505_(0.62695 0.36694 0.58200 0.28889 0.49744 0.65517 0.01562 4.49063
2.47851 0 1)
0506_(0.76172 0.24194 0.10200 1.25000 0.63750 1.41379 0.02344 1.16979
2.56059 1 0)
0511_(0.81250 0.08871 0.32800 1.46154 0.16599 4.09375 0.05078 5.22318
2.35718 0 1)
0511_(0.15625 0.26411 0.44000 1.05263 0.57895 1.29545 0.01953 1.72056
2.53961 0 1)
0517_(0.48438 0.12903 0.11200 1.37500 0.63636 1.34286 0.01953 1.27565
2.53743 1 0)
0517_(0.82617 0.44556 0.36000 1.35714 0.16917 3.30508 0.05078 4.74657
2.62372 0 1)
0519_(0.82031 0.09476 0.25200 1.25000 0.25200 3.34043 0.03516 2.75975
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0519_(0.82422 0.45161 0.43400 1.37037 0.21722 2.91071 0.03906 3.15228
2.60399 0 1)
0520_(0.78125 0.07258 0.21000 2.00000 0.31065 3.42308 0.05078 3.83298
2.59297 0 1)
0521_(0.78320 0.07056 0.17200 2.09091 0.33992 2.85246 0.04297 3.66815
2.59584 0 1)
0521_(0.78125 0.37298 0.10000 1.00000 0.61728 1.35714 0.01953 1.06103
2.47316 1 0)
0523_(0.79297 0.37500 0.09000 1.00000 0.70312 1.41667 0.02344 1.27324
2.42712 1 0)
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0645_( 0.62305 0.34274 1.10800 0.19481 0.47965 0.64103 0.01562 6.16288
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2.75855 0 1)
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2.53724 0 1)
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0669_( 0.82227 0.09274 0.25400 1.38095 0.20854 3.90625 0.04297 3.69353
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0718_( 0.60547 0.05242 0.49000 3.00000 0.31901 0.42105 0.04297 6.60205
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2.55360 0 1)
0733_( 0.81445 0.08669 0.05000 1.16667 0.59524 1.92537 0.07422 1.79049
2.80508 0 1)
0735_( 0.81055 0.08669 0.35200 1.50000 0.17357 3.42105 0.05078 4.94030
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0736_( 0.34570 0.35484 0.82000 0.61765 0.57423 0.85714 0.01562 3.79465
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2.68284 0 1)
0748_( 0.33594 0.47379 0.13600 1.00000 0.56198 0.64865 0.02734 1.41493
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0749_( 0.34180 0.07863 0.73400 0.47619 0.43690 0.89286 0.02344 5.34794
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0750_( 0.76953 0.09476 1.00200 2.11628 0.12803 1.48980 0.03516 9.23714
2.15876 0 1)
0750_( 0.82031 0.09274 0.28200 1.40000 0.25179 3.83333 0.04688 2.93594
2.44606 0 1)
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PROCESSING OUTPUT FEATURE VECTORS FOR IMAGE SET #4- SIDEVIEW

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2.55860 0 1)
0753_( 0.15430 0.26210 0.66600 1.55000 0.53710 1.28889 0.02344 1.68250
2.54395 0 1)
0753_( 0.33203 0.47581 0.06200 0.75000 0.64583 1.24390 0.03906 1.35812
2.48868 0 1)
0755_( 0.73242 0.05444 0.02200 1.66667 0.73333 1.12994 0.07031 1.69765
0.00000 0 1)
0756_( 0.79297 0.10685 1.24000 1.61538 0.14194 1.44681 0.03125 6.51062
2.14177 0 1)
0759_( 0.33203 0.47581 0.06200 0.75000 0.64583 1.28049 0.04688 1.64271
2.52616 0 1)
0760_( 0.82422 0.09274 0.09000 1.20000 0.37500 2.93617 0.05469 2.18270
2.71057 0 1)
0761_( 0.78906 0.07460 0.20600 1.78571 0.29429 3.13208 0.04297 3.53825
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0762_( 0.35156 0.16532 1.25600 0.47059 0.51307 0.83871 0.01562 4.88260
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0765_( 0.50000 0.31452 0.05200 1.20000 0.86667 0.53488 0.03125 1.29977
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0766_( 0.81055 0.08266 0.08000 1.37500 0.45455 2.39583 0.06250 1.59155
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0768_( 0.77930 0.06855 0.20800 1.78571 0.29714 3.23077 0.04688 3.90531
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0775_( 0.82031 0.09274 0.28000 1.34783 0.19635 4.46429 0.05859 3.92174
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0856_( 0.83008 0.09879 0.02000 1.00000 0.62500 1.31683 0.06250 1.29977
2.75432 0 1)
0858_( 0.82812 0.09677 0.18200 1.25000 0.28437 3.96875 0.05078 2.32764
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0859_( 0.78516 0.07258 0.19200 1.84615 0.30769 3.12500 0.04688 3.36772
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2.74382 0 1)
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0871_( 0.83984 0.10282 0.03200 1.00000 0.64000 1.69444 0.06641 1.32629
2.76525 0 1)
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0882_( 0.33594 0.32258 0.92600 0.13699 0.63425 1.16000 0.02734 5.72043
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0892_( 0.83984 0.10282 0.08400 1.00000 0.42000 2.80392 0.05469 1.67113
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0901_(0.81445 0.09073 0.36800 1.37500 0.23232 4.15385 0.04297 3.05319
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0936_( 0.80273 0.27621 0.30800 1.76923 0.51505 1.37143 0.01562 1.72969
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0970_( 0.62305 0.35685 0.83600 0.36957 0.53453 0.62963 0.01562 3.69346
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0986_( 0.16602 0.26008 1.05800 1.03448 0.60805 1.30769 0.01953 1.50452
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0987_( 0.82812 0.44758 0.32600 1.17391 0.26248 2.68750 0.03906 2.78135
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0993_( 0.77148 0.36694 0.29200 1.81818 0.66364 1.11111 0.01172 2.17875
2.47777 0 1)
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0996_( 0.82227 0.09274 0.27400 1.27273 0.22240 4.26667 0.05469 3.23184
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0998_( 0.35352 0.47984 0.29800 2.50000 0.41389 1.01709 0.04688 4.54280
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0998_( 0.62695 0.36694 1.22000 0.39655 0.45727 0.65000 0.01953 3.37331
2.50002 0 1)
0999_( 0.83203 0.09879 0.16200 1.26667 0.28421 3.71429 0.04297 2.47595
2.60991 0 1)
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PROCESSING OUTPUT FEATURE VECTORS FOR IMAGE SET #5 - SIDEVIEW

1001_(0.82031 0.09677 0.28600 1.28571 0.25220 3.39130 0.03516 2.73548 2.48706 0 1)
1004_(0.82031 0.09073 0.26600 1.40909 0.19501 4.40000 0.05078 4.11261 2.42202 0 1)
1004_(0.33398 0.47581 0.07600 1.00000 0.59375 1.21591 0.04688 1.51197 2.56717 0 1)
1004_(0.67969 0.29839 0.09200 0.88889 0.63889 1.55556 0.02734 1.06398 2.50594 0 1)
1004_(0.62305 0.36290 0.82400 0.43902 0.55827 0.62069 0.01953 3.25739 2.49046 0 1)
1005_(0.80078 0.08468 0.39200 1.57692 0.18386 3.61364 0.03906 4.69368 2.32651 0 1)
1005_(0.48633 0.23992 0.09200 1.12500 0.63889 1.33962 0.02344 1.06398 2.57991 0 1)
1007_(0.78320 0.07258 0.20200 1.76923 0.33779 2.88525 0.04688 3.06156 2.59549 0 1)
1007_(0.14844 0.25605 0.08200 1.28571 0.65079 1.81818 0.03125 1.12101 2.57017 0 1)
1007_(0.52734 0.30444 0.09200 1.12500 0.63889 1.35294 0.02734 1.22427 2.53007 0 1)
1009_(0.82617 0.09476 0.20800 1.31579 0.21895 4.06061 0.05469 3.47392 2.49829 0 1)
1009_(0.50000 0.31452 0.05200 0.83333 0.86667 0.56818 0.03906 1.29977 2.73972 0 1)
1010_(0.34766 0.47984 0.22200 1.69231 0.38811 0.93578 0.04688 3.44969 2.40307 0 1)
1011_(0.81641 0.09274 0.36400 1.32000 0.22061 4.22857 0.04688 3.35282 2.40411 0 1)
1013_(0.82617 0.09677 0.18800 1.29412 0.25134 3.75676 0.04688 2.88508 2.55643 0 1)
1013_(0.62109 0.32460 0.33400 0.52174 0.60507 0.91429 0.01953 1.96082 2.54299 0 1)
1014_(0.77344 0.06653 0.17600 1.66667 0.36667 3.06667 0.05078 2.84617 2.58975 0 1)
1016_(0.83203 0.09879 0.05600 1.14286 0.50000 1.85915 0.05469 1.11409 2.79254 0 1)
1016_(0.33008 0.47782 0.49800 3.78571 0.33558 0.99091 0.05469 8.05109 2.37532 0 1)
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1141_( 0.33984 0.12097 0.75400 0.22414 0.50000 0.94828 0.02344 4.55115
2.48947 0 1)
1141_( 0.82227 0.09476 0.26800 1.36842 0.27126 3.70455 0.05078 2.62412
2.47979 0 1)
1141_( 0.53906 0.46169 0.82600 2.47368 0.46249 0.87671 0.01562 3.99005
2.44028 0 1)
1143_( 0.78516 0.07460 0.20600 1.84615 0.33013 2.77049 0.04688 2.95414
2.58435 0 1)
1144_( 0.78906 0.07258 0.01600 1.33333 0.66667 1.35000 0.05859 1.43240
0.00000 0 1)
1144_( 0.83008 0.09476 0.01600 1.33333 0.66667 1.38462 0.10938 1.43240
0.00000 0 1)
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2.57632 0 1)
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1145_( 0.32617 0.47581 0.15600 0.70588 0.38235 0.90265 0.04297 3.35063
2.51654 0 1)
1145_( 0.62500 0.35887 0.80600 0.31373 0.49387 0.62500 0.01953 3.35779
2.47496 0 1)
1146_( 0.62500 0.05847 0.09600 0.63636 0.62338 0.52055 0.03125 1.29977
2.54252 0 1)
1147_( 0.81055 0.08468 0.17600 1.46667 0.26667 3.40541 0.05469 3.26975
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2.14487 0 1)
1148_( 0.82227 0.09677 0.27000 1.19048 0.25714 3.36170 0.03516 2.72602
2.49004 0 1)
1149_( 0.83398 0.09677 0.02000 1.00000 0.62500 1.76000 0.12500 1.29977
2.83966 0 1)
1150_( 0.83398 0.09677 0.02000 1.00000 0.62500 1.62963 0.08984 1.29977
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1150_( 0.09180 0.23790 0.59400 0.32558 0.49336 0.91566 0.03516 3.93909
2.51157 0 1)
1151_( 0.63086 0.05242 0.05200 1.00000 0.53061 0.59551 0.03516 1.62772
2.74165 0 1)
1151_( 0.82617 0.09274 0.14400 1.41667 0.35294 3.04651 0.05469 2.03718
2.63104 0 1)
1151_( 0.33789 0.47984 0.12800 1.30000 0.49231 1.01869 0.04688 1.91213
2.54835 0 1)
1151_( 0.62500 0.37500 0.92800 0.32075 0.51498 0.61290 0.01562 3.46325
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1153_( 0.63867 0.05242 0.10600 2.00000 0.54082 0.68041 0.05078 2.49555
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1157_( 0.33984 0.47984 0.19200 1.33333 0.50000 0.98319 0.05078 2.27364
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1167_( 0.77930 0.06855 0.13200 1.60000 0.41250 2.69697 0.04297 2.39669
2.65444 0 1)
1167_( 0.33008 0.47177 0.06800 0.87500 0.60714 0.77419 0.02734 1.13177
2.65083 0 1)
1169_( 0.34180 0.47984 0.18000 1.15385 0.46154 1.03008 0.05078 2.37328
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1169_( 0.62695 0.36895 0.70400 0.28889 0.60171 0.64103 0.01953 3.15784
2.53805 0 1)
1170_( 0.63281 0.09073 0.63200 0.56522 0.26421 0.80769 0.02734 6.50994
2.34133 0 1)
1171_( 0.80859 0.08468 0.08800 1.25000 0.55000 2.00000 0.06250 1.14910
2.76218 0 1)
1172_( 0.33203 0.10685 0.46600 0.58621 0.47262 1.21429 0.01953 3.02446
2.53682 0 1)
1172_( 0.33398 0.47782 0.17200 1.00000 0.38222 0.68519 0.03125 2.57526
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1173_( 0.82227 0.09476 0.27400 1.25000 0.27400 4.02703 0.04688 2.40676
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1178_( 0.83008 0.09476 0.01000 1.00000 0.55556 1.41176 0.10938 1.27324
0.00000 0 1)
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2.35338 0 1)
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2.48055 0 1)
1187_( 0.34375 0.48185 0.18400 1.54545 0.49198 0.84071 0.04688 2.28373
2.47193 0 1)
1187_( 0.62109 0.36895 0.84400 0.43902 0.57182 0.70000 0.01562 2.52888
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1188_( 0.81250 0.08669 0.15400 1.30769 0.34842 3.07317 0.05469 2.32101
2.64335 0 1)
1189_( 0.32422 0.47984 0.02800 1.25000 0.70000 1.17241 0.05469 1.28916
2.18965 0 1)
1191_( 0.80664 0.08468 0.35400 1.60714 0.14048 3.97059 0.05859 6.92414
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1193_( 0.77930 0.06653 0.11000 1.87500 0.45833 2.41818 0.06250 2.31070
2.65114 0 1)
1193_( 0.82422 0.09476 0.23200 1.31579 0.24421 3.62162 0.04688 2.85173
2.49841 0 1)
1193_( 0.34180 0.47984 0.18000 1.41667 0.44118 1.00000 0.05078 2.54648
2.49693 0 1)
1195_( 0.62109 0.08065 0.23200 0.81250 0.55769 0.71429 0.01953 1.57191
2.53387 0 1)
1195_( 0.77344 0.36290 0.09200 1.00000 0.71875 1.52000 0.01953 1.22427
2.54978 0 1)
1196_( 0.83984 0.10484 0.08000 1.22222 0.40404 2.62264 0.05078 1.59155
2.77638 0 1)
1196_( 0.59375 0.48387 0.65000 2.93333 0.49242 0.92248 0.03906 4.17928
2.50570 0 1)
1197_( 0.79688 0.08065 0.28400 1.70000 0.20882 4.30556 0.04297 4.76298
2.39663 0 1)
1198_( 0.20508 0.23387 0.14600 1.10000 0.66364 1.22222 0.02344 1.38642
2.56712 0 1)
1199_( 0.35547 0.47984 0.29200 2.41667 0.41954 0.95327 0.04688 3.64162
2.36275 0 1)
1200_( 0.78711 0.07258 0.20000 1.64286 0.31056 3.41304 0.04688 2.92990
2.54381 0 1)
1201_( 0.63867 0.08871 0.80800 0.75610 0.31786 0.75000 0.02734 5.39145
2.36394 0 1)
1203_( 0.77930 0.06653 0.06400 1.66667 0.53333 2.16393 0.07031 1.84165
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1205_( 0.33789 0.29839 0.53400 0.18000 0.59333 1.25490 0.02344 5.55362
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2.54745 0 1)
1209_( 0.84180 0.10282 0.01600 0.75000 0.66667 1.60000 0.11719 1.43240
0.00000 0 1)
1210_( 0.78516 0.07258 0.20400 1.76923 0.34114 2.96429 0.05078 2.82710
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1211_( 0.33594 0.48185 0.09800 0.90909 0.44545 0.96269 0.04688 1.61910
2.58997 0 1)
1211_( 0.33984 0.29032 1.06400 0.20513 0.42628 1.35714 0.02344 5.99136
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1211_( 0.62695 0.35685 0.69200 0.28889 0.59145 0.60714 0.01953 2.79027
2.51725 0 1)
1212_( 0.33203 0.46573 0.15800 0.57143 0.70536 0.66667 0.02344 2.04426
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1213_( 0.78320 0.07258 0.18800 1.84615 0.30128 3.03571 0.04297 3.50804
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1217_( 0.33398 0.47984 0.06800 1.00000 0.53125 1.19101 0.04297 1.61145
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1217_( 0.82227 0.09476 0.29000 1.36364 0.21970 3.62162 0.04688 3.37034
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1219_( 0.78320 0.07056 0.17200 2.30000 0.37391 3.01613 0.05859 3.66815
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1221_( 0.62891 0.47581 0.06400 0.75000 0.66667 1.11250 0.03516 1.27324
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1223_( 0.35547 0.47782 0.28800 2.07143 0.35468 0.98131 0.05078 4.07437
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1223_( 0.61914 0.36895 0.93600 0.32727 0.47273 0.60606 0.01562 5.09296
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1225_( 0.33789 0.09677 0.65400 0.21429 0.48661 0.96552 0.02344 4.74825
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1227_( 0.82617 0.11089 0.21000 1.40000 0.33333 1.16364 0.03516 2.37321
2.60123 0 1)
1229_( 0.81445 0.09073 0.31400 1.50000 0.21625 3.95122 0.03516 3.80923
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1229_( 0.33203 0.47984 0.05800 0.55556 0.64444 1.07080 0.04688 1.56707
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1231_( 0.81445 0.09274 0.33800 1.39130 0.22962 3.97368 0.04297 3.23284
2.40606 0 1)
1234_( 0.78320 0.07056 0.16200 1.66667 0.33750 2.78462 0.04297 2.88184
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1235_( 0.35547 0.47984 0.28600 2.41667 0.41092 1.00000 0.05078 3.94804
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2.39916 0 1)
1236_( 0.78125 0.06855 0.08600 1.71429 0.51190 2.19231 0.06641 1.83407
2.73945 0 1)
1236_( 0.83789 0.10282 0.10600 1.18182 0.37063 3.00000 0.05078 1.58057
2.71322 0 1)
1237_( 0.49805 0.13911 0.04400 0.83333 0.73333 0.50000 0.05078 1.14592
2.74277 0 1)
1237_( 0.33203 0.20565 0.53800 0.15094 0.63443 1.34286 0.02344 5.76517
2.53497 0 1)
1240_( 0.78320 0.07056 0.18800 1.76923 0.31438 3.04839 0.04688 3.50804
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1241_( 0.83008 0.10081 0.24200 1.26316 0.26535 3.48718 0.05078 2.37550
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1241_( 0.61523 0.19960 1.26000 0.37313 0.37612 0.64516 0.01562 5.65353
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1242_( 0.77930 0.06653 0.02400 1.25000 0.60000 1.69333 0.05078 1.27324
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2.54380 0 1)
1244_( 0.62695 0.47984 0.09400 1.25000 0.58750 1.14286 0.03516 1.75402
2.62908 0 1)
1246_( 0.75977 0.08266 0.89000 2.44118 0.15769 1.33333 0.03516 8.23483
2.18133 0 1)
1246_( 0.33203 0.08266 0.78600 1.00000 0.17057 0.97826 0.03906 10.14649
 2.10734 0 1)
1246_( 0.82812 0.09476 0.03600 1.00000 0.50000 1.95775 0.06641 0.99472
2.81751 0 1)
1247_( 0.83008 0.09476 0.01600 1.33333 0.66667 1.31429 0.10938 1.43240
0.00000 0 1)
1247_( 0.37891 0.47379 0.86800 4.50000 0.29767 1.06542 0.04297 9.99900
2.33545 0 1)
1250_( 0.83398 0.44153 0.35000 1.27273 0.28409 2.90323 0.04688 2.28802
2.68763 0 1)
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PROCESSING OUTPUT FEATURE VECTORS FOR IMAGE SET #6 - SIDEVIEW

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1251_( 0.77930 0.07056 0.15800 2.00000 0.39500 2.76667 0.04688 3.02594
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2.55362 0 1)
1253_( 0.29492 0.48185 0.08000 1.28571 0.63492 0.84375 0.03906 1.17196
2.45343 0 1)
1254_( 0.81641 0.09274 0.36000 1.32000 0.21818 3.97297 0.04297 3.54482
2.39229 0 1)
1255_( 0.33398 0.20565 0.30400 0.32258 0.49032 1.34211 0.02344 4.56468
2.56160 0 1)
1260_( 0.81836 0.45161 0.40600 1.51852 0.18338 2.91667 0.04688 4.71848
2.62783 0 1)
1261_( 0.31055 0.08065 0.52000 0.84615 0.20202 1.19298 0.04297 10.10878
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1263_( 0.78906 0.07460 0.15600 1.72727 0.37321 2.81356 0.04688 2.65711
2.66878 0 1)
1264_( 0.82812 0.09274 0.04400 1.16667 0.52381 2.07547 0.07812 1.14592
2.80563 0 1)
1265_( 0.50000 0.31250 0.04200 0.83333 0.70000 0.58182 0.03906 1.27324
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2.50776 0 1)
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2.71878 0 1)
1269_( 0.75000 0.32661 0.21800 2.33333 0.57672 0.62963 0.02344 2.09515
2.58445 0 1)
1272_( 0.78711 0.07056 0.04200 1.40000 0.60000 1.86207 0.06250 1.27324
2.76153 0 1)
1272_( 0.82617 0.09274 0.04600 1.16667 0.54762 2.08772 0.06641 1.04174
2.79418 0 1)
1275_( 0.81641 0.08669 0.13600 1.41667 0.33333 3.24390 0.05469 2.26354
2.61412 0 1)
1276_( 0.80664 0.08065 0.06400 1.28571 0.50794 2.11667 0.05859 1.53319
2.77956 0 1)
1277_( 0.77930 0.06653 0.02000 1.00000 0.62500 1.52381 0.05859 1.29977
2.76873 0 1)
1277_( 0.83789 0.10282 0.06600 1.28571 0.52381 2.25000 0.07422 1.43737
2.80405 0 1)
1277_( 0.62891 0.36492 0.71400 0.38636 0.47727 0.69444 0.01562 3.09640
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1279_( 0.78320 0.07258 0.18800 2.09091 0.37154 2.91228 0.05078 3.08124
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1281_( 0.77930 0.06855 0.12200 2.00000 0.47656 2.41333 0.04688 2.31032
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1282_( 0.77930 0.06653 0.09400 1.85714 0.51648 2.15517 0.07422 1.99290
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1285_( 0.82422 0.44960 0.42600 1.32143 0.20560 2.84746 0.03906 3.70629
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1286_( 0.78906 0.07460 0.23800 1.80000 0.29383 3.45652 0.04688 3.21161
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1289_( 0.81445 0.09073 0.27000 1.41667 0.16544 4.55172 0.04297 5.49204
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1301_( 0.81250 0.09274 0.38200 1.50000 0.22106 4.14286 0.04297 3.59380
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1306_( 0.83008 0.09476 0.01600 1.33333 0.66667 1.30476 0.09375 1.43240
0.00000 0 1)
1306_( 0.50000 0.31452 0.05400 0.71429 0.77143 0.62500 0.03516 1.19978
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1307_( 0.77539 0.06855 0.08600 1.57143 0.55844 2.02500 0.05469 1.83407
2.76695 0 1)
1308_( 0.78711 0.07258 0.17800 1.66667 0.37083 3.00000 0.04688 2.59845
2.60666 0 1)
1309_( 0.82227 0.09274 0.05800 1.14286 0.51786 1.95312 0.06250 1.27892
2.78877 0 1)
1310_( 0.78320 0.07258 0.19800 1.84615 0.31731 3.23077 0.04297 3.38052
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1311_( 0.83008 0.09476 0.01600 1.33333 0.66667 1.35789 0.11719 1.43240
0.00000 0 1)
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1315_(0.82617 0.09476 0.21400 1.25000 0.21400 4.15625 0.05078 3.69609
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1317_(0.78516 0.07258 0.19600 1.92308 0.30154 3.19298 0.04688 3.66693
2.58299 0 1)
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2.78692 0 1)
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0.00000 0 1)
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APPENDIX F

ANN INPUT SETS FOR TRAINING SETS 1, 2, AND 6

ANN INPUT SETS FOR TRAINING SET 1 - SIDEVIEW

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pi*area fr_dim y/n
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( 0.19727 0.21774 0.13000 1.22222 0.65657 1.81818 0.02734 1.11797 2.596
18 1 0)
( 0.65430 0.25605 0.09000 1.28571 0.71429 1.58065 0.02734 1.27324 2.558
65 1 0)
( 0.81836 0.09073 0.28000 1.43478 0.18445 4.79167 0.05078 4.28881 2.393
30 0 1)
( 0.35352 0.26815 0.06200 1.16667 0.73810 1.54286 0.02344 1.11906 2.408
75 1 0)
( 0.81445 0.08669 0.22000 1.42105 0.21442 3.68966 0.05859 3.92164 2.455
05 0 1)
( 0.77930 0.06653 0.06400 1.66667 0.53333 2.21569 0.06641 1.84165 2.750
96 0 1)
( 0.83203 0.09879 0.17200 1.18750 0.28289 4.20690 0.04688 2.22330 2.588
28 0 1)
( 0.16211 0.27016 0.46800 1.56250 0.58500 1.36667 0.01953 2.13906 2.537
59 0 1)
( 0.68555 0.25605 0.29600 1.84615 0.47436 1.13636 0.01172 3.40354 2.467
15 0 1)
( 0.16211 0.26815 0.53800 1.44444 0.57479 1.33333 0.01953 1.64811 2.529
48 0 1)
( 0.82812 0.09677 0.20000 1.37500 0.28409 3.76471 0.05078 2.58138 2.542
34 0 1)
( 0.83008 0.09879 0.19800 1.23529 0.27731 3.66667 0.04297 2.46272 2.547
24 0 1)
( 0.62500 0.35081 0.94200 0.25000 0.52333 0.69697 0.01562 4.79418 2.506
34 0 1)
( 0.32617 0.09476 0.60400 0.32759 0.27405 1.07692 0.03125 9.24070 2.235
72 0 1)
( 0.30469 0.33065 0.10200 1.00000 0.62963 1.52381 0.02734 1.02681 2.561
04 1 0)
( 0.80273 0.07863 0.09800 1.33333 0.45370 2.56522 0.07422 1.83347 2.717
68 0 1)
( 0.71875 0.31855 0.07800 1.28571 0.61905 1.69565 0.02344 1.04536 2.532
86 1 0)
( 0.81836 0.09073 0.28800 1.43478 0.18972 4.10714 0.04688 4.44410 2.386
51 0 1)
( 0.78320 0.07056 0.19400 1.76923 0.32441 3.34694 0.04688 3.30169 2.578
64 0 1)
( 0.33398 0.09476 0.37200 0.22857 0.66429 0.86765 0.02344 3.61868 2.554
48 0 1)
( 0.83203 0.09677 0.03200 0.83333 0.53333 1.82090 0.08203 1.32629 2.803
76 0 1)
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( 0.82031 0.09476 0.28400 1.47368 0.26692 4.00000 0.04688 2.76692 2.491
36 0 1)
( 0.84180 0.18952 0.09200 1.14286 0.82143 1.32000 0.01953 1.40375 2.446
97 1 0)
( 0.84570 0.18548 0.19600 1.27273 0.63636 1.25806 0.01172 1.54734 2.450
77 1 0)
( 0.80664 0.08871 0.47200 1.59259 0.20327 4.29730 0.04297 3.92370 2.331
60 0 1)
( 0.81250 0.09073 0.36000 1.45833 0.21429 3.92308 0.04297 3.54482 2.373
24 0 1)
( 0.88281 0.26210 0.66800 0.12329 0.50837 1.02817 0.03906 9.19567 2.376
25 0 1)
( 0.82422 0.09476 0.22000 1.36842 0.22267 4.00000 0.03906 3.31573 2.467
93 0 1)
( 0.81836 0.09073 0.28600 1.45455 0.20312 4.03030 0.04297 3.94804 2.387
45 0 1)
( 0.83008 0.09476 0.01600 1.33333 0.66667 1.39286 0.12109 1.43240 0.000
00 0 1)
( 0.82031 0.09274 0.25200 1.33333 0.21429 3.91429 0.04688 3.56507 2.435
44 0 1)
( 0.82617 0.09476 0.23600 1.31579 0.24842 3.66667 0.05078 2.92564 2.494
76 0 1)
( 0.81836 0.45363 0.21800 1.25000 0.34063 2.12941 0.04297 1.96720 2.732
82 0 1)
( 0.82812 0.10081 0.20800 1.11111 0.28889 3.00000 0.03125 2.26411 2.549
74 0 1)
( 0.81445 0.08669 0.06000 1.14286 0.53571 1.96825 0.04297 1.19366 2.770
43 0 1)
( 0.62305 0.34879 0.88400 0.27119 0.46822 0.66667 0.01562 4.55549 2.492
41 0 1)
( 0.82031 0.09677 0.31800 1.33333 0.27041 3.70000 0.04297 2.42287 2.472
04 0 1)
( 0.82031 0.09677 0.29600 1.21739 0.22981 3.75000 0.03516 2.97443 2.440
59 0 1)
( 0.82227 0.44556 0.52600 1.18919 0.16155 2.77419 0.03906 4.75573 2.554
88 0 1)
( 0.82227 0.09274 0.26600 1.38095 0.21839 4.32258 0.05078 3.40194 2.446
25 0 1)
( 0.62500 0.36290 0.72200 0.34146 0.62892 0.68571 0.01562 2.63351 2.520
58 0 1)
( 0.58789 0.05242 0.50400 3.43750 0.28636 0.51852 0.04297 8.26894 2.457
74 0 1)
( 0.82031 0.09879 0.47800 1.32353 0.15621 3.92105 0.03906 4.45258 2.273
61 0 1)
( 0.62109 0.17540 0.85600 0.34783 0.58152 0.71429 0.01562 2.71623 2.468
01 0 1)
( 0.62695 0.37097 0.70800 0.31915 0.50213 0.63889 0.01953 3.44284 2.528
30 0 1)
( 0.80078 0.08468 0.41000 1.56667 0.14539 3.52381 0.03516 6.33466 2.277
99 0 1)
( 0.81445 0.45766 0.35000 1.45000 0.30172 2.43243 0.04688 2.38801 2.692
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37 0 1)
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00 0 1)
( 0.78711 0.07056 0.03600 1.20000 0.60000 1.72059 0.07031 1.37555 2.782
46 0 1)
( 0.80469 0.08669 0.42000 1.51724 0.16458 3.70732 0.04688 5.20937 2.308
83 0 1)
( 0.81055 0.08871 0.37400 1.38462 0.19979 3.89744 0.04297 3.85634 2.359
30 0 1)
( 0.62695 0.47984 0.08600 1.00000 0.67188 1.11957 0.04688 1.38396 2.403
46 0 1)
( 0.82812 0.09677 0.14400 1.28571 0.28571 3.13636 0.03906 2.42083 2.610
59 0 1)
( 0.84375 0.36895 0.12200 1.12500 0.84722 1.47826 0.02344 1.23883 2.459
48 1 0)
( 0.82422 0.09476 0.21600 1.36842 0.21862 4.46667 0.04688 3.43007 2.486
66 0 1)
( 0.38086 0.29435 0.14600 0.90909 0.66364 1.95833 0.02344 0.93544 2.506
27 1 0)
( 0.80859 0.43347 0.12400 1.37500 0.70455 1.24074 0.02344 1.07940 2.499
57 1 0)
( 0.40039 0.21371 0.10800 1.25000 0.67500 1.58140 0.03125 1.06345 2.517
15 1 0)
( 0.71484 0.27823 0.12000 1.00000 0.74074 2.03226 0.03125 1.13774 2.534
96 1 0)
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08 1 0)
( 0.66016 0.37702 0.10400 1.12500 0.72222 1.91304 0.02734 1.13205 2.559
39 1 0)
( 0.50000 0.31250 0.03800 0.83333 0.63333 0.51020 0.03516 1.20361 2.733
24 0 1)
( 0.83008 0.09879 0.18000 1.25000 0.28125 3.85294 0.05078 2.37328 2.569
95 0 1)
( 0.82031 0.09476 0.28600 1.40000 0.25536 4.17143 0.04688 3.14940 2.456
18 0 1)
( 0.17969 0.23185 0.14600 1.22222 0.73737 2.05128 0.02734 1.26113 2.531
37 1 0)
( 0.80664 0.38306 0.10000 1.00000 0.61728 1.31429 0.01953 1.37555 2.529
14 1 0)
( 0.70898 0.11089 0.10400 1.57143 0.67532 1.50000 0.01953 1.28385 2.476
21 1 0)
( 0.62891 0.37500 0.65200 0.28261 0.54515 0.65714 0.01953 2.87839 2.520
02 0 1)
( 0.82227 0.09476 0.25800 1.52632 0.23412 4.31034 0.04688 3.41856 2.456
46 0 1)
( 0.82422 0.44758 0.42000 1.19355 0.18309 2.78689 0.03906 4.04735 2.603
26 0 1)
( 0.83203 0.09879 0.02000 1.00000 0.62500 1.35165 0.05859 1.29977 2.717
51 0 1)
( 0.50000 0.31452 0.04800 0.85714 0.57143 0.59615 0.03125 1.22260 2.696
60 0 1)
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( 0.12109 0.43145 0.12400 1.07692 0.34066 2.41053 0.05078 1.83496 2.709
14 0 1)
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14 0 1)
( 0.82031 0.09476 0.28200 1.28571 0.24868 3.90000 0.04297 2.79909 2.470
93 0 1)
( 0.62305 0.36895 0.96200 0.35294 0.52397 0.56000 0.01562 3.36293 2.503
70 0 1)
( 0.81250 0.09073 0.35400 1.45833 0.21071 4.02564 0.03516 3.37584 2.376
65 0 1)
( 0.33984 0.09879 0.96800 0.34545 0.46316 0.86792 0.02344 3.52897 2.321
63 0 1)
( 0.77539 0.06653 0.16000 2.10000 0.38095 2.91525 0.04688 3.18310 2.615
17 0 1)
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24 0 1)
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86 0 1)
( 0.62305 0.35081 0.97600 0.27419 0.46300 0.58621 0.01562 3.96520 2.450
95 0 1)
( 0.82422 0.45161 0.43400 1.37037 0.21722 2.80000 0.04297 3.37011 2.615
63 0 1)
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53 0 1)
( 0.77148 0.06653 0.19400 1.76923 0.32441 2.96610 0.05469 3.09893 2.568
91 0 1)
( 0.83203 0.43750 0.49800 1.12121 0.20393 3.11765 0.04297 3.01359 2.610
67 0 1)
( 0.78516 0.07258 0.21400 1.92308 0.32923 3.27451 0.05469 3.10757 2.569
21 0 1)
( 0.82031 0.09274 0.27600 1.38095 0.22660 3.88235 0.04688 3.19194 2.432
69 0 1)
( 0.60352 0.06048 0.34000 1.83333 0.64394 0.50000 0.01562 1.73934 2.537
63 0 1)
( 0.81250 0.08871 0.32200 1.45833 0.19167 4.00000 0.03906 4.28494 2.383
01 0 1)
( 0.34180 0.20161 0.76200 0.40816 0.38878 1.21951 0.02344 4.76103 2.480
47 0 1)
( 0.82031 0.09476 0.28000 1.40000 0.25000 3.92105 0.04688 2.97089 2.453
50 0 1)
( 0.82227 0.09476 0.28200 1.35000 0.26111 4.15789 0.05469 2.54015 2.474
50 0 1)
( 0.78125 0.07258 0.23600 1.73333 0.30256 3.13559 0.05078 3.26027 2.548
17 0 1)
( 0.62305 0.35685 0.95600 0.29091 0.54318 0.63889 0.01953 3.65671 2.511
66 0 1)
( 0.63477 0.05847 0.18000 1.41667 0.44118 0.49275 0.03906 2.92447 2.574
24 0 1)
( 0.83203 0.09677 0.01600 1.33333 0.66667 1.31915 0.10938 1.43240 0.000
00 0 1)
( 0.78320 0.07258 0.16600 1.81818 0.37727 2.79032 0.04688 2.75085 2.640
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54 0 1)
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34 0 1)
( 0.11328 0.42339 0.17200 1.00000 0.29758 2.60000 0.04688 2.39396 2.629
49 0 1)
( 0.62500 0.37097 0.90800 0.29412 0.59346 0.69444 0.01562 2.74047 2.505
78 0 1)
( 0.80859 0.09073 0.38000 1.40741 0.18519 4.13158 0.03516 4.32277 2.346
15 0 1)
( 0.77148 0.06452 0.07400 1.83333 0.56061 1.95455 0.05859 1.87241 2.761
61 0 1)
( 0.78320 0.07056 0.01600 1.33333 0.66667 1.25472 0.05859 1.43240 0.000
00 0 1)
( 0.82812 0.09677 0.03400 1.20000 0.56667 1.51852 0.07422 1.60481 2.772
85 0 1)
( 0.58594 0.05444 0.71600 3.00000 0.33056 0.40323 0.03516 5.55630 2.410
44 0 1)
( 0.77539 0.06452 0.10200 1.75000 0.45536 2.68889 0.07031 2.15178 2.682
70 0 1)
( 0.80664 0.46774 0.01600 1.33333 0.66667 1.05882 0.13281 1.43240 0.000
00 0 1)
( 0.79492 0.07661 0.11800 1.66667 0.43704 2.32877 0.04297 2.23082 2.717
40 0 1)
( 0.80078 0.24194 0.78200 1.21739 0.60714 0.61111 0.01562 1.87891 2.451
78 0 1)
( 0.62695 0.32460 0.72200 0.22222 0.55710 0.69697 0.01562 4.85456 2.546
26 0 1)
( 0.50000 0.31250 0.04400 0.83333 0.73333 0.64286 0.03906 1.14592 2.726
24 0 1)
( 0.79297 0.47177 0.11400 1.18182 0.39860 1.78218 0.05078 2.15134 2.754
58 0 1)
( 0.81055 0.09073 0.33400 1.52174 0.20745 4.08108 0.04297 4.01990 2.380
01 0 1)
( 0.62695 0.33065 0.98000 0.12500 0.61250 0.63158 0.01562 6.87102 2.523
19 0 1)
( 0.83984 0.10484 0.07600 1.11111 0.42222 2.59615 0.06250 1.51197 2.771
05 0 1)
( 0.25586 0.37903 0.64200 1.23810 0.58791 0.77273 0.01562 2.71696 2.505
05 0 1)
( 0.66602 0.28629 0.07400 1.00000 0.57812 1.54167 0.02344 1.14990 2.493
67 1 0)
( 0.82422 0.09476 0.22000 1.36842 0.22267 3.82857 0.05078 3.31573 2.495
81 0 1)
( 0.79688 0.07460 0.05600 1.33333 0.58333 2.03390 0.06641 1.37730 2.774
69 0 1)
( 0.62695 0.39315 0.13800 0.90909 0.62727 0.79167 0.01953 1.38124 2.544
40 0 1)
( 0.78906 0.07460 0.21200 1.78571 0.30286 3.52083 0.05078 3.55257 2.543
84 0 1)
( 0.80859 0.08871 0.29800 1.52381 0.22173 4.06977 0.03516 3.67260 2.433
80 0 1)
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( 0.71484 0.42137 0.16400 1.20000 0.68333 1.73529 0.02344 1.05476 2.497
64 1 0)
( 0.82422 0.09476 0.21600 1.36842 0.21862 3.72222 0.04297 3.43007 2.483
37 0 1)
( 0.70703 0.45766 0.02800 1.25000 0.70000 0.65854 0.03906 1.28916 2.718
42 0 1)
( 0.62500 0.37097 0.68000 0.34884 0.52713 0.67568 0.01953 3.64708 2.545
73 0 1)
( 0.62109 0.09879 0.99600 0.43860 0.34947 0.73585 0.02344 6.02717 2.265
88 0 1)
( 0.82617 0.09274 0.02000 1.00000 0.62500 1.54945 0.10547 1.29977 2.800
54 0 1)
( 0.62500 0.35282 0.70200 0.28261 0.58696 0.63636 0.01562 3.17042 2.526
40 0 1)
( 0.64258 0.05444 0.20400 3.71429 0.56044 0.58537 0.04297 4.56190 2.751
25 0 1)
( 0.31836 0.09073 0.84400 0.37500 0.48843 0.60377 0.02734 4.02652 2.337
76 0 1)
( 0.81250 0.09274 0.38800 1.44000 0.21556 3.92308 0.04688 3.50470 2.370
99 0 1)
( 0.77734 0.06855 0.19000 1.76923 0.31773 3.36735 0.04688 3.43645 2.585
51 0 1)
( 0.77930 0.23185 0.20400 1.70000 0.60000 1.25000 0.01562 2.05361 2.487
59 0 1)
( 0.82031 0.09476 0.30600 1.27273 0.24838 4.00000 0.04297 2.81788 2.430
14 0 1)
( 0.81250 0.09073 0.34000 1.36000 0.20000 3.97368 0.03906 4.05202 2.360
72 0 1)
( 0.75781 0.30645 0.25400 0.93750 0.52917 1.20000 0.01562 1.65147 2.498
90 0 1)
( 0.78516 0.07258 0.19400 1.69231 0.33916 3.03333 0.04688 2.90683 2.586
03 0 1)
( 0.81641 0.45766 0.14600 1.36364 0.44242 1.98947 0.05859 1.66558 2.773
41 0 1)
( 0.78711 0.07258 0.17600 1.83333 0.33333 3.00000 0.04297 3.05163 2.566
74 0 1)
( 0.83008 0.10081 0.20000 1.20000 0.37037 3.00000 0.04688 1.61145 2.631
93 0 1)
( 0.50000 0.31250 0.05000 1.00000 0.69444 0.58824 0.03125 1.12072 2.706
34 0 1)
( 0.82031 0.09476 0.29000 1.33333 0.24660 3.80000 0.03906 2.80399 2.462
40 0 1)
( 0.81445 0.09274 0.36600 1.39130 0.24864 3.72727 0.04688 2.84928 2.408
69 0 1)
( 0.50000 0.31250 0.04000 0.83333 0.66667 0.54717 0.04297 1.06988 2.733
51 0 1)
( 0.80078 0.08065 0.30000 1.69565 0.16722 4.62963 0.05859 6.21135 2.358
59 0 1)
( 0.50000 0.31250 0.04400 0.83333 0.73333 0.57407 0.03125 1.14592 2.711
12 0 1)
( 0.59961 0.05444 0.62200 2.89474 0.29761 0.49275 0.03906 6.54323 2.411
```

```
15 0 1)
( 0.81250 0.09073 0.41200 1.46154 0.20850 4.71875 0.04297 3.53569 2.351
65 0 1)
( 0.62500 0.30847 0.47400 0.33333 0.54861 1.25714 0.01562 3.45212 2.518
61 0 1)
( 0.79102 0.07460 0.14800 1.72727 0.35407 2.87719 0.04297 2.71401 2.650
18 0 1)
( 0.78906 0.07258 0.16400 1.66667 0.34167 3.12727 0.04688 2.61159 2.605
21 0 1)
( 0.82617 0.09879 0.24800 1.29412 0.33155 3.43478 0.05078 1.81653 2.559
88 0 1)
( 0.82812 0.09879 0.24000 1.23529 0.33613 3.18000 0.03906 1.91089 2.585
61 0 1)
( 0.81836 0.08669 0.13800 1.46154 0.27935 3.08108 0.05469 3.12523 2.579
55 0 1)
( 0.50000 0.31250 0.04200 1.00000 0.58333 0.54167 0.03125 0.96289 2.707
75 0 1)
( 0.11914 0.41935 0.38000 0.86207 0.26207 3.03448 0.04297 2.90426 2.474
54 0 1)
( 0.77148 0.06452 0.07800 1.83333 0.59091 2.00000 0.05469 1.94965 2.753
59 0 1)
( 0.33398 0.21169 0.42600 0.28205 0.49650 1.34286 0.02344 4.35271 2.559
17 0 1)
( 0.84180 0.43347 0.33400 0.96429 0.22090 2.77966 0.03906 3.03695 2.648
12 0 1)
( 0.50000 0.31452 0.05400 0.71429 0.77143 0.61404 0.04297 1.19978 2.742
77 0 1)
```

ANN INPUT SETS FOR TRAINING SET 2 - SIDEVIEW

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( 0.78516 0.07258 0.19800 1.92308 0.30462 3.26000 0.04297 3.59503 2.578
42 0 1)
( 0.78516 0.07056 0.18000 1.91667 0.32609 3.40385 0.05078 3.34918 2.575
11 0 1)
( 0.78320 0.07056 0.21600 1.71429 0.32143 3.21818 0.05078 3.05578 2.539
78 0 1)
( 0.33008 0.46371 0.09800 0.50000 0.68056 0.75806 0.02734 2.07233 2.684
34 0 1)
( 0.50000 0.31250 0.04400 0.83333 0.73333 0.50000 0.03516 1.14592 2.716
65 0 1)
( 0.81641 0.09476 0.38800 1.37037 0.19419 4.67742 0.04297 3.76154 2.376
77 0 1)
( 0.83008 0.09879 0.17000 1.20000 0.31481 4.03125 0.05078 2.10474 2.621
15 0 1)
( 0.69727 0.41331 0.08600 1.00000 0.67188 1.90909 0.02344 1.03132 2.495
65 1 0)
( 0.50000 0.31452 0.05200 0.85714 0.61905 0.54348 0.03516 1.03451 2.702
44 0 1)
( 0.62891 0.36492 0.68200 0.29545 0.59615 0.66667 0.01562 2.91946 2.478
18 0 1)
( 0.82422 0.44960 0.30600 1.42857 0.24286 2.75000 0.04297 2.94691 2.689
40 0 1)
( 0.82031 0.09274 0.23200 1.33333 0.19728 4.56667 0.04297 3.94626 2.449
52 0 1)
( 0.50000 0.31452 0.04600 1.00000 0.63889 0.62264 0.03125 1.04174 2.696
59 0 1)
( 0.82422 0.09476 0.22600 1.30000 0.21731 3.52778 0.03906 3.33841 2.464
64 0 1)
( 0.50000 0.31250 0.04400 0.83333 0.73333 0.55769 0.03906 1.14592 2.743
96 0 1)
( 0.82812 0.09879 0.20600 1.26316 0.22588 3.96970 0.04688 3.33358 2.522
47 0 1)
( 0.82422 0.09274 0.11400 1.36364 0.34545 3.00000 0.06641 2.39017 2.685
55 0 1)
( 0.84180 0.43347 0.37400 0.96667 0.21494 2.94444 0.03906 2.86479 2.634
67 0 1)
( 0.82031 0.09476 0.31600 1.33333 0.26871 3.94737 0.04688 2.44662 2.456
89 0 1)
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( 0.81836 0.09073 0.29800 1.43478 0.19631 4.32258 0.05078 4.00256 2.408
76 0 1)
```

```
( 0.82812 0.09476 0.04400 1.16667 0.52381 2.00000 0.05859 1.14592 2.807
69 0 1)
( 0.80664 0.46774 0.01600 1.33333 0.66667 1.08947 0.15234 1.43240 0.000
00 0 1)
( 0.49805 0.31452 0.04800 0.71429 0.68571 0.60000 0.04688 1.22260 2.743
83 0 1)
( 0.77539 0.06653 0.16600 2.10000 0.39524 2.81667 0.05078 2.96102 2.613
37 0 1)
( 0.83984 0.10484 0.07600 1.25000 0.47500 2.34545 0.04297 1.28916 2.770
78 0 1)
( 0.82617 0.09476 0.23600 1.35000 0.21852 4.21875 0.05469 3.43897 2.466
92 0 1)
( 0.62500 0.37702 0.65800 0.27907 0.63760 0.66667 0.01562 2.91638 2.537
34 0 1)
( 0.62109 0.05444 0.18800 1.72727 0.44976 0.53409 0.03906 3.28866 2.619
12 0 1)
( 0.32422 0.17339 0.22600 0.68421 0.45749 1.20000 0.01562 1.97711 2.535
54 0 1)
( 0.82227 0.09476 0.26200 1.31579 0.27579 3.51111 0.03906 2.58726 2.513
66 0 1)
( 0.61914 0.06048 0.08200 1.14286 0.73214 0.71875 0.01953 1.12101 2.537
65 0 1)
( 0.80664 0.46371 0.28000 1.36842 0.28340 2.27160 0.04297 2.83202 2.706
41 0 1)
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ANN INPUT SETS FOR TRAINING SET 6 - SIDEVIEW

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( 0.77930 0.07056 0.15800 2.00000 0.39500 2.76667 0.04688 3.02594 2.662
78 0 1)
( 0.81445 0.08468 0.16400 1.50000 0.27891 3.44118 0.06250 3.03153 2.553
62 0 1)
( 0.29492 0.48185 0.08000 1.28571 0.63492 0.84375 0.03906 1.17196 2.453
43 0 1)
( 0.81641 0.09274 0.36000 1.32000 0.21818 3.97297 0.04297 3.54482 2.392
29 0 1)
( 0.33398 0.20565 0.30400 0.32258 0.49032 1.34211 0.02344 4.56468 2.561
60 0 1)
( 0.81836 0.45161 0.40600 1.51852 0.18338 2.91667 0.04688 4.71848 2.627
83 0 1)
( 0.31055 0.08065 0.52000 0.84615 0.20202 1.19298 0.04297 10.10878 2.24
671 0 1)
( 0.78906 0.07460 0.15600 1.72727 0.37321 2.81356 0.04688 2.65711 2.668
78 0 1)
( 0.82812 0.09274 0.04400 1.16667 0.52381 2.07547 0.07812 1.14592 2.805
63 0 1)
( 0.50000 0.31250 0.04200 0.83333 0.70000 0.58182 0.03906 1.27324 2.725
81 0 1)
( 0.62305 0.10081 0.21800 0.47619 0.51905 1.34615 0.01562 2.67279 2.507
76 0 1)
( 0.62695 0.47782 0.09600 0.80000 0.60000 1.10112 0.03906 1.29977 2.477
31 0 1)
( 0.81445 0.09073 0.31600 1.43478 0.20817 4.18421 0.03906 3.76782 2.411
99 0 1)
( 0.83789 0.10282 0.10600 1.18182 0.37063 3.15385 0.05469 1.58057 2.718
78 0 1)
( 0.75000 0.32661 0.21800 2.33333 0.57672 0.62963 0.02344 2.09515 2.584
45 0 1)
( 0.78711 0.07056 0.04200 1.40000 0.60000 1.86207 0.06250 1.27324 2.761
53 0 1)
( 0.82617 0.09274 0.04600 1.16667 0.54762 2.08772 0.06641 1.04174 2.794
18 0 1)
( 0.81641 0.08669 0.13600 1.41667 0.33333 3.24390 0.05469 2.26354 2.614
12 0 1)
( 0.80664 0.08065 0.06400 1.28571 0.50794 2.11667 0.05859 1.53319 2.779
56 0 1)
( 0.77930 0.06653 0.02000 1.00000 0.62500 1.52381 0.05859 1.29977 2.768
73 0 1)
( 0.83789 0.10282 0.06600 1.28571 0.52381 2.25000 0.07422 1.43737 2.804
05 0 1)
( 0.62891 0.36492 0.71400 0.38636 0.47727 0.69444 0.01562 3.09640 2.490
80 0 1)
( 0.78320 0.07258 0.18800 2.09091 0.37154 2.91228 0.05078 3.08124 2.637
39 0 1)
( 0.82031 0.09476 0.31600 1.27273 0.25649 4.05405 0.04688 2.67699 2.445
14 0 1)
( 0.77930 0.06855 0.12200 2.00000 0.47656 2.41333 0.04688 2.31032 2.684
40 0 1)
( 0.77930 0.06653 0.09400 1.85714 0.51648 2.15517 0.07422 1.99290 2.713
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66 0 1)
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24 0 1)
( 0.82812 0.09274 0.02000 1.00000 0.62500 1.74026 0.10156 1.29977 2.803
81 0 1)
( 0.82422 0.44960 0.42600 1.32143 0.20560 2.84746 0.03906 3.70629 2.605
93 0 1)
( 0.78906 0.07460 0.23800 1.80000 0.29383 3.45652 0.04688 3.21161 2.525
37 0 1)
( 0.82422 0.09476 0.22400 1.31579 0.23579 3.80556 0.04688 3.03279 2.496
82 0 1)
( 0.81445 0.08669 0.18600 1.53333 0.26957 3.52632 0.05469 3.14412 2.544
68 0 1)
( 0.81445 0.09073 0.27000 1.41667 0.16544 4.55172 0.04297 5.49204 2.397
43 0 1)
( 0.81836 0.09274 0.28000 1.34783 0.19635 4.38710 0.05469 3.92174 2.422
93 0 1)
( 0.82617 0.09476 0.24000 1.30000 0.23077 4.13793 0.05859 2.99973 2.474
51 0 1)
( 0.62695 0.35887 0.51000 0.32432 0.57432 0.64286 0.01562 2.65065 2.498
68 0 1)
( 0.63086 0.05444 0.18200 1.21429 0.38235 0.46739 0.04688 3.06539 2.521
31 0 1)
( 0.82031 0.45161 0.42000 1.29630 0.22222 2.72059 0.03906 3.09539 2.637
58 0 1)
( 0.83203 0.09879 0.04000 1.40000 0.57143 1.75676 0.07422 1.43240 2.802
05 0 1)
( 0.83398 0.09677 0.02800 1.00000 0.56000 1.85333 0.09375 1.28916 2.832
00 0 1)
( 0.81250 0.09274 0.38200 1.50000 0.22106 4.14286 0.04297 3.59380 2.348
62 0 1)
( 0.82227 0.44758 0.38600 1.34615 0.21209 2.65079 0.03906 3.28812 2.635
30 0 1)
( 0.17188 0.22782 0.18200 1.45455 0.51705 0.82609 0.01953 1.87514 2.566
91 0 1)
( 0.83008 0.09879 0.15800 1.30769 0.35747 3.12963 0.04297 1.88391 2.672
07 0 1)
( 0.83008 0.09476 0.01600 1.33333 0.66667 1.30476 0.09375 1.43240 0.000
00 0 1)
( 0.50000 0.31452 0.05400 0.71429 0.77143 0.62500 0.03516 1.19978 2.695
76 0 1)
( 0.77539 0.06855 0.08600 1.57143 0.55844 2.02500 0.05469 1.83407 2.766
95 0 1)
( 0.78711 0.07258 0.17800 1.66667 0.37083 3.00000 0.04688 2.59845 2.606
66 0 1)
( 0.82227 0.09274 0.05800 1.14286 0.51786 1.95312 0.06250 1.27892 2.788
77 0 1)
( 0.78320 0.07258 0.19800 1.84615 0.31731 3.23077 0.04297 3.38052 2.594
73 0 1)
( 0.83008 0.09476 0.01600 1.33333 0.66667 1.35789 0.11719 1.43240 0.000
00 0 1)
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10 0 1)
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78 0 1)
( 0.63672 0.05040 0.23800 2.90000 0.41034 0.41121 0.04688 4.61682 2.665
09 0 1)
( 0.82617 0.09476 0.21400 1.25000 0.21400 4.15625 0.05078 3.69609 2.471
12 0 1)
( 0.78516 0.07258 0.19600 1.92308 0.30154 3.19298 0.04688 3.66693 2.582
99 0 1)
( 0.75781 0.30444 0.10600 1.00000 0.65432 1.31034 0.01953 1.09668 2.503
79 1 0)
( 0.82812 0.09677 0.18600 1.25000 0.29063 3.26190 0.04297 2.24143 2.548
82 0 1)
( 0.83984 0.43750 0.26400 1.04762 0.28571 2.55385 0.03516 2.18270 2.703
48 0 1)
( 0.34375 0.09476 0.79000 0.31034 0.37835 0.98148 0.02734 5.89679 2.190
62 0 1)
( 0.77148 0.06452 0.13600 1.70000 0.40000 2.67647 0.04688 2.47600 2.642
77 0 1)
( 0.85352 0.28024 0.08000 1.12500 0.55556 1.50000 0.02734 0.99991 2.518
55 1 0)
( 0.62695 0.28629 0.17400 0.50000 0.67969 0.74194 0.01562 1.73569 2.565
03 0 1)
( 0.81055 0.08266 0.07800 1.37500 0.44318 2.61702 0.06641 1.67532 2.742
36 0 1)
( 0.61523 0.05040 0.66200 7.09091 0.38578 0.57282 0.04688 10.86279 2.66
322 0 1)
( 0.79883 0.07460 0.04800 1.16667 0.57143 2.15254 0.07812 1.55972 2.786
92 0 1)
( 0.80859 0.08669 0.32400 1.52000 0.17053 3.74286 0.04688 5.14510 2.367
01 0 1)
( 0.78125 0.07056 0.19600 1.69231 0.34266 3.34615 0.05469 3.04046 2.598
27 0 1)
( 0.58594 0.04839 0.49000 4.50000 0.37809 0.53333 0.04297 6.60205 2.586
51 0 1)
( 0.31250 0.30645 0.82200 0.50000 0.51375 1.24138 0.01562 3.26825 2.515
88 0 1)
( 0.77930 0.06653 0.09600 1.85714 0.52747 2.23077 0.07031 2.16243 2.694
98 0 1)
( 0.84180 0.10484 0.07400 1.12500 0.51389 2.32692 0.05469 1.14990 2.784
23 0 1)
( 0.61328 0.05040 0.15800 2.22222 0.43889 0.53261 0.04297 3.02594 2.690
80 0 1)
( 0.77734 0.06855 0.20200 1.76923 0.33779 3.16393 0.04688 3.06156 2.585
94 0 1)
( 0.62305 0.36694 0.59200 0.33333 0.50340 0.62857 0.01562 4.26765 2.530
47 0 1)
( 0.59570 0.04839 0.41400 3.53846 0.34615 0.45455 0.04297 6.03742 2.585
75 0 1)
( 0.78516 0.07258 0.18400 1.57143 0.29870 3.07273 0.03906 3.42861 2.555
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93 0 1)
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84 0 1)
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87 0 1)
( 0.62891 0.32661 0.13600 0.90909 0.61818 1.29730 0.01953 1.71602 2.554
83 0 1)
( 0.50000 0.31452 0.05600 0.85714 0.66667 0.60377 0.03906 1.11409 2.720
76 0 1)
( 0.62695 0.36089 0.49600 0.35294 0.60784 0.71875 0.01562 2.34392 2.533
20 0 1)
( 0.81445 0.45766 0.12200 1.60000 0.38125 2.18478 0.05078 2.54913 2.778
44 0 1)
( 0.82227 0.09073 0.03200 1.00000 0.64000 1.67532 0.07031 1.32629 2.767
20 0 1)
( 0.82422 0.09476 0.23800 1.30000 0.22885 4.12500 0.05078 3.04384 2.474
96 0 1)
( 0.62305 0.36492 0.68800 0.36957 0.43990 0.63636 0.01562 4.69647 2.510
48 0 1)
( 0.50000 0.31452 0.05800 0.85714 0.69048 0.62000 0.03906 1.27892 2.703
30 0 1)
( 0.81641 0.09274 0.32600 1.39130 0.22147 4.58065 0.04688 3.43077 2.417
75 0 1)
( 0.67578 0.05847 0.23200 3.50000 0.51786 0.53846 0.04297 4.38216 2.696
32 0 1)
( 0.77734 0.07056 0.01600 1.33333 0.66667 1.18621 0.05078 1.43240 0.000
00 0 1)
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04 0 1)
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57 0 1)
( 0.83984 0.10685 0.08400 1.11111 0.46667 2.36207 0.03906 1.24902 2.775
08 0 1)
( 0.80273 0.08669 0.39000 1.55556 0.17196 3.70000 0.03906 5.22680 2.314
96 0 1)
( 0.79297 0.36694 0.20600 1.63636 0.52020 1.12903 0.01562 2.45231 2.474
63 0 1)
( 0.81836 0.09274 0.31600 1.30435 0.22899 4.40000 0.04297 3.05266 2.422
00 0 1)
( 0.82422 0.09476 0.23000 1.36842 0.23279 3.94286 0.05469 3.06067 2.496
41 0 1)
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23 0 1)
( 0.83984 0.10484 0.07200 1.12500 0.50000 2.49057 0.05469 1.21042 2.790
78 0 1)
( 0.81250 0.09073 0.32600 1.39130 0.22147 4.10000 0.04297 3.43077 2.410
73 0 1)
( 0.78125 0.07056 0.19200 2.00000 0.28402 3.68000 0.05078 4.32487 2.575
28 0 1)
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78 0 1)
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```
( 0.62109 0.36895 0.73600 0.37209 0.53488 0.62500 0.01562 2.76290 2.493
43 0 1)
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56 0 1)
( 0.62305 0.32258 0.36400 0.62500 0.50556 1.22500 0.01562 2.44717 2.539
94 0 1)
( 0.82617 0.09476 0.17400 1.31250 0.25893 3.71053 0.05078 2.90804 2.564
34 0 1)
( 0.32812 0.08266 0.69600 0.83333 0.18125 1.15385 0.03906 10.08645 2.13
146 0 1)
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08 0 1)
( 0.60742 0.05040 0.38000 4.18182 0.37549 0.57273 0.04688 6.87290 2.655
50 0 1)
( 0.76367 0.27823 0.12200 0.90000 0.67778 2.25000 0.01953 1.10780 2.491
22 1 0)
( 0.50000 0.31452 0.05000 0.71429 0.71429 0.63462 0.04297 1.12072 2.738
96 0 1)
( 0.62695 0.06048 0.10600 0.81818 0.53535 0.59322 0.02734 1.77628 2.612
45 0 1)
( 0.79297 0.07460 0.18200 1.57143 0.29545 3.73333 0.05469 3.27792 2.569
28 0 1)
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12 0 1)
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52 0 1)
( 0.76953 0.06452 0.06400 1.50000 0.59259 1.84946 0.05469 1.84165 2.777
97 0 1)
( 0.75000 0.29032 0.29600 0.70000 0.52857 2.25000 0.01953 1.32429 2.573
51 1 0)
( 0.83203 0.09879 0.16200 1.26667 0.28421 3.31429 0.03906 2.47595 2.611
88 0 1)
( 0.80469 0.08669 0.37000 1.57692 0.17355 3.85366 0.03516 5.02027 2.327
76 0 1)
( 0.77148 0.06653 0.14000 2.00000 0.43210 2.55385 0.05078 2.55532 2.684
00 0 1)
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19 0 1)
( 0.81055 0.09073 0.41400 1.40741 0.20175 4.02703 0.04297 3.75310 2.346
02 0 1)
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74 0 1)
( 0.52344 0.31855 0.12922 1.33333 0.60185 1.08511 0.01953 1.52663 2.567
29 1 0)
( 0.72461 0.30040 0.17893 0.92308 0.57692 1.50000 0.01953 1.09713 2.540
94 1 0)
( 0.16992 0.30242 0.10139 1.12500 0.70833 1.25000 0.02734 1.16979 2.528
27 1 0)
( 0.66016 0.25202 0.06362 1.14286 0.57143 1.24138 0.01953 1.27324 2.590
74 1 0)
( 0.21094 0.24194 0.26839 0.72222 0.57692 1.17647 0.01953 1.79049 2.554
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42 0 1)
( 0.80859 0.21774 0.99602 2.44444 0.63258 2.12821 0.01562 1.81083 2.547
72 1 0)
( 0.83008 0.09879 0.17200 1.26667 0.30175 3.18605 0.03516 2.22330 2.616
43 0 1)
( 0.79102 0.07661 0.18600 1.69231 0.32517 3.03846 0.04297 3.14412 2.607
88 0 1)
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96 1 0)
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55 0 1)
( 0.23047 0.26613 0.07000 1.14286 0.62500 1.61538 0.02344 1.27766 2.503
44 1 0)
( 0.23438 0.29234 0.08600 1.14286 0.76786 1.35714 0.02344 1.03132 2.555
98 1 0)
( 0.78320 0.07056 0.21200 1.71429 0.31548 3.40816 0.04688 3.35203 2.539
20 0 1)
( 0.78516 0.07056 0.20800 1.78571 0.29714 3.46154 0.04688 3.47392 2.538
67 0 1)
( 0.32812 0.21169 0.08800 1.12500 0.61111 1.58065 0.02344 1.14910 2.484
13 1 0)
( 0.72852 0.29032 0.09800 1.12500 0.68056 1.82609 0.02344 1.09762 2.487
66 1 0)
( 0.61914 0.36492 0.91200 0.45455 0.51818 0.59259 0.01562 3.41047 2.482
51 0 1)
( 0.83984 0.10081 0.02000 1.00000 0.62500 1.74194 0.11719 1.29977 2.817
98 0 1)
( 0.63281 0.05242 0.09000 2.00000 0.62500 0.65979 0.04297 2.18270 2.780
47 0 1)
( 0.24805 0.21976 0.08600 1.14286 0.76786 1.78571 0.02344 1.38396 2.434
26 1 0)
( 0.73438 0.25202 0.11800 1.00000 0.72840 2.00000 0.02734 1.04096 2.566
93 1 0)
( 0.81250 0.09274 0.38400 1.33333 0.19753 3.75610 0.03516 3.96241 2.361
44 0 1)
( 0.84570 0.31048 0.16400 1.87500 0.68333 1.23077 0.01562 1.62975 2.550
52 0 1)
( 0.81055 0.33065 0.46600 1.68750 0.53935 0.85294 0.01562 1.52971 2.480
88 0 1)
( 0.33203 0.46976 0.11200 0.80000 0.70000 0.88235 0.01953 1.27565 2.562
77 0 1)
( 0.82227 0.09476 0.27800 1.30000 0.26731 3.77500 0.03516 2.59922 2.450
97 0 1)
( 0.75195 0.28831 0.11400 0.90000 0.63333 1.22857 0.01953 0.97482 2.501
36 1 0)
( 0.34375 0.37298 0.88400 0.50000 0.55250 0.72222 0.01562 3.21839 2.492
93 0 1)
( 0.59180 0.04839 0.52600 3.25000 0.31611 0.68493 0.04297 6.29339 2.459
15 0 1)
( 0.79688 0.07460 0.03400 1.20000 0.56667 1.78788 0.07422 1.13682 2.810
62 0 1)
```

```
( 0.62695 0.34476 0.25800 0.50000 0.64500 0.75758 0.01562 1.81250 2.533
45 0 1)
( 0.81836 0.08871 0.16400 1.42857 0.29286 3.15385 0.05859 2.81482 2.565
25 0 1)
( 0.82617 0.09476 0.23000 1.31579 0.24211 3.93548 0.04688 3.06067 2.494
77 0 1)
( 0.62500 0.35887 0.66800 0.26531 0.52433 0.61290 0.01562 4.20205 2.503
53 0 1)
( 0.33594 0.32258 0.57400 0.20833 0.59792 1.23256 0.01953 4.14861 2.541
06 0 1)
( 0.12695 0.43145 0.25800 1.35294 0.32992 2.61842 0.04297 2.02875 2.584
68 0 1)
( 0.83789 0.10282 0.10600 1.08333 0.33974 3.12195 0.05078 1.77628 2.690
93 0 1)
( 0.83008 0.09677 0.03200 1.20000 0.53333 1.66667 0.06641 1.32629 2.767
65 0 1)
( 0.80078 0.08266 0.25600 1.61111 0.24521 3.32653 0.04297 3.82427 2.462
48 0 1)
( 0.74219 0.05444 0.15000 2.00000 0.46296 2.30588 0.05859 2.64442 2.631
71 0 1)
( 0.82422 0.09476 0.21600 1.26316 0.23684 3.73529 0.04297 3.23840 2.499
87 0 1)
( 0.75195 0.28629 0.23200 0.70588 0.56863 2.10811 0.01953 1.20349 2.594
08 1 0)
( 0.62695 0.27419 0.17600 0.56250 0.61111 0.72414 0.01562 1.45513 2.572
52 0 1)
( 0.62500 0.37298 0.76200 0.31111 0.60476 0.57576 0.01562 2.83194 2.506
01 0 1)
( 0.81445 0.45968 0.29800 1.47368 0.28008 2.64789 0.05078 2.56087 2.705
90 0 1)
( 0.78516 0.07056 0.18800 1.83333 0.35606 3.28302 0.05078 2.88508 2.572
86 0 1)
( 0.82422 0.09073 0.06800 1.12500 0.47222 2.36957 0.05859 1.91517 2.758
45 0 1)
( 0.50000 0.31250 0.04800 0.83333 0.80000 0.54000 0.03516 1.22260 2.720
78 0 1)
( 0.80078 0.08266 0.27600 1.61905 0.19328 3.97059 0.05469 5.03132 2.430
96 0 1)
( 0.82031 0.45363 0.24400 1.29412 0.32620 2.30864 0.04688 1.86252 2.736
13 0 1)
( 0.08398 0.25605 0.12200 0.40000 0.67778 0.75652 0.04688 2.80991 2.785
90 0 1)
( 0.82617 0.09677 0.18600 1.29412 0.24866 3.26190 0.03906 3.14412 2.555
12 0 1)
( 0.18359 0.16935 0.15800 1.20000 0.65833 1.22222 0.01953 1.59321 2.580
17 0 1)
( 0.82227 0.09274 0.11600 1.27273 0.37662 2.81250 0.05859 1.87136 2.683
25 0 1)
( 0.81445 0.09073 0.33400 1.37500 0.21086 4.05263 0.03906 3.57224 2.386
79 0 1)
( 0.42969 0.43548 0.16000 0.91667 0.60606 1.10526 0.01953 1.43240 2.554
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```
55 0 1)
( 0.78320 0.07258 0.19600 1.84615 0.31410 3.00000 0.04688 3.23819 2.597
33 0 1)
( 0.77344 0.23185 0.14800 1.20000 0.61667 1.31034 0.01953 1.23430 2.511
63 1 0)
( 0.77344 0.06653 0.14600 1.90000 0.38421 2.81356 0.05078 3.02616 2.644
60 0 1)
( 0.82227 0.09476 0.31400 1.28571 0.27690 3.92105 0.04688 2.36002 2.471
67 0 1)
( 0.82227 0.09476 0.28800 1.30000 0.27692 3.84211 0.03906 2.57831 2.457
61 0 1)
( 0.82031 0.09476 0.29600 1.33333 0.25170 3.89744 0.04297 2.84118 2.459
69 0 1)
( 0.31445 0.22581 0.11600 1.11111 0.64444 1.96296 0.02734 1.34814 2.561
78 1 0)
( 0.59180 0.24395 0.16400 1.20000 0.68333 2.32353 0.02734 1.05476 2.550
45 1 0)
( 0.30859 0.41129 0.08800 1.12500 0.61111 1.31034 0.02734 1.32629 2.560
25 1 0)
( 0.76953 0.26411 0.09800 1.12500 0.68056 2.10526 0.02344 1.09762 2.421
35 1 0)
( 0.15039 0.30444 0.10400 1.00000 0.64198 1.28947 0.02734 0.99472 2.582
13 1 0)
( 0.62500 0.34476 0.36600 0.52174 0.66304 0.68000 0.01562 1.71949 2.504
42 0 1)
( 0.78320 0.07056 0.19600 1.76923 0.32776 3.18000 0.05859 3.23819 2.573
64 0 1)
( 0.32812 0.31048 0.22400 0.47368 0.65497 1.23256 0.01953 1.76839 2.552
41 0 1)
( 0.61914 0.07863 0.37800 0.61905 0.69231 0.60714 0.01562 2.13084 2.524
10 0 1)
( 0.10547 0.30040 0.05800 1.60000 0.72500 0.69767 0.03125 1.27892 2.700
42 0 1)
( 0.83008 0.09476 0.01600 1.33333 0.66667 1.40230 0.08594 1.43240 0.000
00 0 1)
```

APPENDIX G

ANN OUTPUT FOR TRAINING SETS 1 + 2 + 3 AND TEST SET 3

		Pixel Location x	y	Probability of Detection	
IMAGE=501	AUA= 1	(394	, 32)	result=(0.000000	1.000000)
IMAGE=504	AUA= 2	(400	, 34)	result=(0.000000	1.000000)
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IMAGE=505	AUA= 4	(422	, 47)	result=(0.000000	1.000000)
IMAGE=505	AUA= 5	(320	,182)	result=(0.000000	1.000000)
IMAGE=506	AUA= 6	(390	,120)	result=(0.832702	0.167299)
IMAGE=511	AUA= 7	(416	, 44)	result=(0.000003	0.999997)
IMAGE=511	AUA= 8	(80	,130)	result=(0.000000	1.000000)
IMAGE=517	AUA= 9	(248	, 63)	result=(0.998539	0.001461)
IMAGE=517	AUA= 10	(422	,220)	result=(0.000000	1.000000)
IMAGE=519	AUA= 11	(419	, 47)	result=(0.000000	1.000000)
IMAGE=519	AUA= 12	(422	,223)	result=(0.001834	0.998166)
IMAGE=520	AUA= 13	(400	, 35)	result=(0.000000	1.000000)
IMAGE=521	AUA= 14	(400	, 34)	result=(0.000000	1.000000)
IMAGE=521	AUA= 15	(400	,184)	result=(0.999687	0.000313)
IMAGE=523	AUA= 16	(406	,186)	result=(0.999817	0.000183)
IMAGE=523	AUA= 17	(422	,223)	result=(0.001720	0.998280)
IMAGE=524	AUA= 18	(423	, 47)	result=(0.000005	0.999995)
IMAGE=525	AUA= 19	(323	, 26)	result=(0.000000	1.000000)
IMAGE=525	AUA= 20	(400	, 34)	result=(0.000000	1.000000)
IMAGE=526	AUA= 21	(42	,124)	result=(0.000000	1.000000)
IMAGE=527	AUA= 22	(422	, 47)	result=(0.000000	1.000000)
IMAGE=527	AUA= 23	(64	,215)	result=(0.001715	0.998285)
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IMAGE=537	AUA= 32	(85	,128)	result=(0.000248	0.999752)
IMAGE=538	AUA= 33	(416	, 44)	result=(0.000006	0.999994)
IMAGE=540	AUA= 34	(428	, 50)	result=(0.000005	0.999995)
IMAGE=540	AUA= 35	(256	,155)	result=(0.000000	1.000000)
IMAGE=542	AUA= 36	(422	, 47)	result=(0.000000	1.000000)
IMAGE=544	AUA= 37	(402	, 35)	result=(0.000001	0.999999)
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IMAGE=548	AUA= 40	(211	,120)	result=(0.998900	0.001100)
IMAGE=548	AUA= 41	(320	,197)	result=(0.967945	0.032055)
IMAGE=549	AUA= 42	(403	,158)	result=(0.390374	0.609627)
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IMAGE=555	AUA= 48	(418	, 44)	result=(0.000000	1.000000)
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IMAGE=557	AUA= 51	(44	,127)	result=(0.000000	1.000000)

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